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JOURNAL
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Volume XL AUGUST, 1958 Number 3

POLICY FOR COMMERCIAL AGRICULTURE RE-EXAMINED: A REVIEW ARTICLE*

MARION CLAWSON
Resources for the Future

A RECENT report, *Policy for Commercial Agriculture, Its Relation to Economic Growth and Stability* (Joint Committee Print, Joint Economic Committee, 85th Congress, 1st Session, November 22, 1957) is a highly valuable up-to-date review of agricultural policy by a large number of the nation's leading agricultural economists. Every agricultural economist now interested in agricultural policy or likely to become so in the future should send his $2.25 to the Government Printing Office for a copy. It is well worth it; I judge this will shortly become one of the classics in the field. It is timely today, excellent as a reference source, and will acquire historical value with time. It is a magnificent intellectual product, in about as poor wrappings as a good piece of writing ever suffered.[1]

I wish to examine first the setting for this study, secondly the participants, thirdly to summarize the major findings under a few headings, and lastly to speculate upon the effect that it may have upon policy formulation for agriculture.

The Setting for This Study

There are several facts concerning this study which should be borne in mind when reading it. First of all, it was done at the direction of the Joint Economic Committee, no member of which is a member of the

* The views expressed herein are personal only.

[1] The Government Printing Office, or it and the Committee staff jointly, have turned out the usual miserable Congressional report. Though 864 pages in length, it lacks a hard cover, and a name along the back to identify it when on a shelf. There are no Part or Chapter headings, though there are 10 parts and 60 papers or Chapters and, lastly, there is no index. All you can do is to turn to the Table of Contents. One who knows or suspects its contents may find what he seeks; strangers, enter at your peril!

House Committee on Agriculture or of the Senate Committee on Agriculture and Forestry. I interpret it as a major effort to take a fresh and full look at agricultural policy, as free from preconception and bias as human intellectual effort can be. Perhaps such an effort is too much for the specialized committees most concerned with agriculture. A major characteristic of our political system is that each pressure or interest group tries to get the committees and key spots of the Executive branch most concerned with its affairs staffed with its "friends." This may insure you friendly treatment, but it also leads to a sterility of thinking; when all think more or less alike, perhaps no one thinks at all. I have noted elsewhere that some of the most original work concerning the public lands in recent years has come from a committee other than the specialized ones most directly concerned.[2] While it is difficult to get Congressional interest from members and committees not previously directly involved, perhaps there is more chance of the general public interest being served in this than in any other way.

The present report is a companion piece to an earlier one by the same Subcommittee, entitled *Low-Income Families* (Hearings before the Subcommittee on Low-Income Families of the Joint Committee on the Economic Report, 84th Congress, 1st Session, November 1955). The earlier one considered low income families wherever located. The present one considers commercial farming, defined in the 1954 Census to include those farms with $2,500 or more sales; these farms are 44 per cent of the total number and produce 91 per cent of the total output. The definitions used are not hard and fast, and sometimes the discussion includes smaller farms as well. The emphasis, however, is on the commercial farms; hence, much of the policy considered is production and price policy.

For this study, the Subcommittee employed one of the able younger agricultural economists of this country, George E. Brandow of Pennsylvania State University. This in itself is excellent, and while not precisely an innovation for Congressional committees, is all too uncommon as a means of staffing for best results.

Some 67 persons were invited to prepare some 60 papers. The papers were available to each author and to the Subcommittee members and were discussed at a series of panel meetings in mid-December 1957. Those who prepared papers and the members of the Subcommittee who could be present engaged in a half-day discussion on each of the 10 panel subjects. These panel discussions are also published, under the same title as the report here under review, but identified further as Hearings before the Subcommittee on Agricultural Policy of the Joint Economic Commit-

[2] Marion Clawson and Burnell Held, *The Federal Lands, Their Use and Management*. Johns Hopkins Press, Baltimore, 1957, p. 148.

tee, 85th Congress, 1st Session, December 16 to 20, 1957. I attended none of these panel discussions, but from reading the printed record it seems that they must have been unusually productive. One is struck by the courteous, thoughtful, intelligent discussion, particularly on the part of the members of Congress. These men knew their subject, understood the discussions, and tried to make the most of the intellectual offerings of the specialists. The Hearings are relatively lengthy, 376 pages.

The Subcommittee has issued a Report, with the same general title, dated February 10, 1958, of the 85th Congress, 2nd Session. The report is comparatively brief, 26 pages. Six pages are a dissent by Senator Watkins, a member of the Subcommittee who could not be present during the panel discussions. His dissent is couched in mild and sensible terms, and is more a matter of relative emphasis on certain points than an outright disagreement with the majority report.

All in all, from an organizational viewpoint, the job was well done.

The Participants

Before taking up the findings of the study, a few words about the participants seem desirable. The most striking thing about them, to this reviewer at least, was their comparative youthfulness. Based upon the information in our Association's *1956 Handbook*, it was possible to know the age of 50 of the 67 participants. For this group, the modal age was about 45 years; nearly half were 40 to 49, with almost exactly as many between 30 and 39 as between 50 and 59; and only three were over 60 years of age. Policy demands intellectual maturity perhaps more than any other field of research, and to me it is striking that such an able group of young men exists. I suppose it is impossible to measure ability in this field, but I would agree that some of the best, if not all the best, men in the field were represented here. We have a new generation of agricultural economists, men who have mostly come into professional activity only since large-scale national agricultural programs came into being, to provide our intellectual leadership. Of those who helped to provide leadership for the Federal Farm Board and early New Deal programs, only John D. Black, Oscar C. Stine, and Murray R. Benedict are included in the present study. With such comparatively young men now in such strong intellectual leadership roles, we can be sure that agricultural policy for the next decade or two will be heavily influenced by these men.

Of the 67 total participants, 39 were from agricultural colleges; 10 were from some federal agency; seven from the major national farm organizations, and the remainder from other employment—including one Iowa farmer, whose statement and discussion were on a fully equivalent plane with that of the professionals. Five of the papers were prepared by

men from Michigan State University, four each from Iowa State College (but this included six men) and University of California, and lesser numbers from several other agricultural colleges.

On the whole, the papers bear evidence that the invitation to present a paper to this report was taken seriously. There is a notable absence of fluff and filler in the papers and of attempted rhetoric, but instead a refreshing coming-down to facts and ideas. Moreover, not only in the papers but in the discussion, while there was an attempt to arrive at consensus, one gets the feeling that no one refrained from expressing his clearly held convictions on the subjects discussed.

The Findings

The papers in the volume here under review, and the subsequent panel discussions were organized into 10 major chapters or sections, with three to seven papers in each, as follows:

I. The farm problem and its relation to economic growth and development
II. The current and prospective market position of agriculture
III. Adjustment problems faced by commercial farmers in major geographic areas
IV. Changing market costs and structure; marketing agreements and orders
V. Assistance to farmers in making farm and personal adjustments
VI. Adjusting agriculture through the price mechanism
VII. Price and income standards for farm programs
VIII. Programs to expand domestic demand or to utilize foreign outlets for farm products
IX. Direct payments to producers; comprehensive versus commodity-by-commodity programs
X. Adjusting production through administrative controls

A generalization which covers all the papers is that they are more notable for their succinct summary of relevant ideas and facts than they are for their novelty. This is not intended as criticism; the purpose of this series of papers was to review the present policy position of agriculture, and this is best served by a careful and balanced review of the present situation. There were, however, some papers which contained material new at least to this reviewer and others which, while covering familiar ground, were so clearly stated as to qualify as new in their total impact. Nathan M. Koffsky and Ernest W. Grove present income series for high-production commercial farms, those with gross sales of $2,500 or more, and for low-production farms, or for all farms with less than $2,500 sales, whether classed as commercial or not. These data show that these two groups of farm families differ as to level of their incomes, the proportions coming from farm and from nonfarm sources, and as to trend in the last five or six years. These data, while preliminary and possibly subject to greater error than the older series, are an important contribu-

tion; they are, in a sense, a logical extension of the classification of farms into economic groupings which has characterized census data for the past two or three censuses, but nevertheless an important extension. Dale Hathaway presents much data new to this reviewer on the relation of agriculture and the business cycle. And I would characterize Karl Fox's discussion of demand curves as so informative and so clear as to be a new contribution, although there is little in it which price analysts have not known for some time.

A major consensus appears out of these papers on a number of points. It is not easy for a reviewer to formulate agreement from papers with different subjects; at the best, his summarization of different points will reflect to some extent what he looks for in the papers, as well as what the authors intended. The authors were not asked to choose among various carefully formulated choices to specific questions, nor even to write essays on the same subject matter, except in a very general and broad way. Hence, one must infer at many points what an author probably would have said to a specific question. But a surprising amount of agreement on general matters among these selected 67 scholars is evident.[3]

The consensus revealed by these papers can perhaps best be summarized on a time basis; for past agricultural trends, for the present agricultural situation, and for the future of agriculture.

1. *As to past agricultural trends.* There was complete agreement, as far as I could see, that the demand for agricultural commodities is highly inelastic, especially at the farm; and, as far as specific elasticity ratios were cited, there seemed agreement on their relative magnitude. This conclusion will hardly come as a surprise to well-informed agricultural economists, but it seemed to be accepted equally by the members of Congress who participated in the panels. More importantly, they *understood* what this meant. It is true that Herrell DeGraff plumped for aggressive salesmanship of farm products, that Wheeler McMillen presented a glowing picture of new uses and new crops, and that John Baker and some others put more stress on food stamp, school lunch, and other subsidized food consumption programs as a partial solution to farm surplus problems, than did the group as a whole. But even these men accepted the idea of a generally inelastic demand for farm commodities.

There was also general agreement that the supply function for agriculture is highly inelastic, perhaps only slightly less so or possibly more so, than the demand function. The compulsion of the individual farmer to

[3] In this connection, it is interesting and possibly significant that three authors of papers and the staff member of the Committee were four or five members of a committee of our Association which rejected the idea of ascertaining a consensus of *all* Association members on many of these same questions.

use his labor, capital, land, and other resources to the limit of his capabilities, regardless of what this did to the total supply situation and to agricultural prices, was well established and illustrated by several authors. The role of the time factor, in permitting more adjustment, especially upward, with longer periods of time, was also well recognized. And the downward extreme inelasticity of agricultural output was also generally accepted. Elmer Working presented perhaps the most extreme view as to the effectiveness of relative prices in bringing about adjustments in agricultural output, but even he recognized that prices operate slowly in this regard and that other factors may be highly important.

There was also virtually complete agreement that the dominant factor in past increases in agricultural output had been developments in agricultural technology. This was well illustrated in Carl P. Heisig's paper on long-term adjustments and in the several papers on adjustments needed in different regions. There were many other references and illustrations in other papers of the same point; in fact, the papers as a group could be criticized in that the impact of technology was discussed at several points but not fully in any one place. The fact that more corn is now grown on 30 million less acres than 25 or 30 years ago was brought out by Warren E. Collins of the American Farm Bureau Federation (but only in a footnote), and that as much or more wheat is grown now on 25 to 30 million acres less than previously, and that the saving in cotton acreage required for the same output is in the order of 20 million acres, are also brought out at scattered points through the papers.

There was also virtually unanimous agreement that acreage control programs in the past had had little or no effect upon total agricultural output, and only limited effect upon output of particular commodities. The tendency to substitute fertilizer, labor, and machinery for land was mentioned by several as explaining the much smaller change in output of a commodity than of the area used for its production; and the possibility of shifting land from one crop to another was identified as one of the reasons for the smaller adjustment in total output than in that for any single commodity. Moreover, the unwillingness of farmers and legislators to establish and impose production controls "with teeth" was widely recognized.

2. *As to present agricultural situation.* There was unanimous agreement that the present situation in agriculture is unsatisfactory—unsatisfactory to farmers, to farm leaders, to farm specialists, and to the general public. The symptoms of the disease are the stationary or declining farm incomes at a time when nonfarm incomes have been rising, the large accumulated surpluses, and the high and rising costs of the program. The learned doctors may not agree as to the cause of the patient's illness nor

as to the cure for it, but they all agree he is ill! It is true that the degree of discontent seems to vary: I would put Murray Benedict and Elmer Working on the side of those who think the illness is not as bad as the likely nostrums for its cure, while possibly John Baker is most unhappy about it. All the farm organization representatives agree that what we have, we don't want; but they disagree considerably as to what to do about it.

Almost equally unanimous is the agreement that there are certain rather fundamental imbalances between agriculture and the rest of the economy and within agriculture. There is, it seems to me, general recognition that agriculture has been and is now in the midst of rather profound changes, internally and in its relation to the rest of the economy. Reference was made to agricultural revolution at several points. Though perhaps not explicitly stated, there seems to be fairly general recognition that changes of the magnitude and rapidity which agriculture is experiencing are bound to bring serious imbalances; change simply does not occur at the same rate in all sectors. I think there was fairly good agreement also that some long range and relatively fundamental changes were inevitable, and probably desirable, but that the problem was to lessen their impact without at the same time creating even more severe dislocations.

There seemed nearly complete agreement that we have large excess capacity in agriculture today, which is not merely temporary but nearly chronic. The future of productive capacity will be discussed later. While several authors emphasized the role of World War II and the Korean war as stimulating output beyond present needs, there seemed also fairly good agreement that this was not the only factor, nor perhaps even the major factor, in the present excess productive capacity. The fact that the latter was not temporary was stressed in several places. I think that most authors would agree, though most did not deal with it directly, that output could be raised still more and rather quickly, if there were need for it and if prices were high enough. Possibly the most significant aspect of this unanimity or near unanimity was that, in the panel discussions, it extended to the Congressmen. As far as these particular Congressmen are concerned, it seems clear that there is an acceptance that the agricultural surplus is neither a mirage nor a temporary headache.

There was also high agreement that there are in agriculture today far more workers than are needed to produce the present or any reasonably foreseeable outputs of the future. This came out of several papers, perhaps in none better than the one by J. H. Blackstone, dealing with the problems of the Southeast. This is the region where the problem is most acute, but it is heartening to one resident outside that region to see the

clarity with which this author sees the problem, and the concern and sympathy he has that the farm people involved shall not suffer needless hardship in making adjustments dictated by stern economic forces. But virtually every regional discussion emphasized the same general situation. Earl Heady makes it clear that, even in the Corn Belt, a third or more of the present farm labor force could be withdrawn without reduction in present output or without impairment of capacity to expand output in the future—such withdrawal presumably could not occur suddenly, but within a few years. Moreover, as the panel discussions and the report of the Subcommittee make clear, these particular Congressmen also agreed with these conclusions. They were troubled by the past migration from farms—it had reduced the number of Congressional districts in Arkansas and Missouri, and threatened to do so in Alabama. To anyone familiar with national politics, this is deep trouble indeed. Moreover, these men were genuinely and sincerely concerned with the human adjustment problems which the statistics on migration from farms documented. But they, at least, did not deny the facts nor demand the clock be turned back. In our discussion of the future, we shall return to this point.

There was also fairly high agreement that our present foreign trade programs in agricultural commodities are unsound—unsound as a solution to difficult basic problems within agriculture, but especially unsound as programs for the world's richest nation engaged in a difficult political contest with another leading nation. The adverse effects of our dumping—and that is what it is, and that is what many of them called it—on our friends was described in some detail. I found Larry Witt's paper on multiple-price plans in general, and Helen Farnsworth's discussion of multiple pricing of wheat exports, each most enlightening. Even those of us generally familiar with present agricultural programs often are surprised at the length to which state trading has proceeded for agriculture in this country. In an effort to cure our agricultural headache, we have engaged in programs of selling crops abroad which cannot but negate our other, and to me more important, efforts toward international peace.

I was pleased to see the way several papers, including a staff paper in the Appendix, made clear that the large changes now under way in agriculture have not significantly changed the role the family farm occupies. Family farms are today much bigger than they once were, both in terms of area and in terms of income at constant prices, and they purchase from nonfarmers many specialized services which they once did for themselves; but their labor supply, both family and hired, is slightly smaller. Some of the managerial decisions once made by the farmer are now made off the farm, it is true. But talk about growth of corporation farming, or of factory farming, or of disappearance of the family farmer is greatly exaggerated, to put it in the mildest possible terms.

3. *As to the future of agriculture.* The major function of this study was apparently not to formulate a program for agriculture, but to review the present position.[4] There was no general outlining of future agricultural program, although some of the farm organization and other representatives did this to some degree; it was obvious that unanimity on proposals for future action would have been impossible. Some of the analyses bear directly or by implication on the future, however, and several judgments as to the future had general agreement.

First of all, virtually everyone expects total agricultural output to continue to rise and this almost irrespective of the level of farm prices. The most probable situation seems to be that an actual, or at least a potential, surplus of farm products will continue for at least a decade. I am unable to find any statement which clearly takes an opposite view, and there are several which explicitly take this stand. Beyond a decade or so, there seems to have been much less thinking and much less of a consensus. But, again, no one clearly expects shortages of agricultural commodities, or even great difficulty in meeting probable demands; on the contrary, there seems implicit in several statements a continuation of an agricultural surplus situation. Some statements almost sound as if agricultural productive capacity was a juggernaut, out of control and likely to run us all down. As in some of the earlier points, what impressed me most was the acceptance by the Congressmen of this view.

Though virtually everyone accepts surpluses as nearly inevitable, no one argues that we should plan to produce them. A few feel that the seriousness of the surpluses is exaggerated, or that they have their advantages as compared with shortages and scarcities—a kind of whistling in the dark. Nearly everyone seems tacitly to accept the idea that programs drastic enough to abolish the surpluses would bring other and even more undesirable consequences. There were some proposals for dealing with the surpluses which do not fall in this category and which we will consider later.

There was almost unanimous agreement that a continued movement of people out of agriculture was probable and desirable. Over and over again, the statement was made that more people were trying to make a living out of agriculture than were needed to produce the volume of goods society wants from agriculture, and that this general relationship would continue into the future even with continued large scale migration from agriculture. Moreover, there was general agreement that this out-

[4] This study is marred, at least to a slight degree, because nowhere does the reader learn exactly what the authors were asked to write on; one can only infer that they addressed themselves to the subjects assigned, but sometimes one cannot but wonder. In an introductory statement, the Subcommittee chairman stated that "the current study looks toward a better understanding of the complex farm problem and the implications of dealing with it rather than toward specific legislative proposals."

movement might well be aided, not so much to increase its volume but to reduce the personal and social costs involved in relocation and to improve the land use in the remaining areas. Again, I was impressed by the fact that the Congressmen present did not dispute this viewpoint; one could hardly say they were pleased with the situation, partly because of its political implications but more because of its humanitarian ones, but they did not rebel.

A major part of Senator Watkins' dissent in the Subcommittee report is devoted to a stronger statement of the need to help people who should move out of agriculture. He quotes an interesting statement from the Cache County Farm Bureau of his home state of Utah, recognizing the inevitability of out-migration from agriculture. To this reviewer, this marks a most interesting change of viewpoint in one of our most agriculturally fundamentalist states. In the early 1930's, while stationed at Utah agricultural college for the BAE, I prepared a table showing the number of persons who had migrated from each Utah county in the preceding decade. With a rather sharply limited resource base and a high birth rate, migration was the best adjustment of people to resources. But that table stirred up a lot of discussion among county agents and farm people, almost all of which was to the effect that this was a most undesirable trend, about which they should strive to do something. Times do change.

Though nearly everyone believes we will have many fewer people in agriculture in the future than are there today, yet almost no one thinks this alone will solve the major problems of commercial agriculture. Statements to the effect that aid to those who should leave agriculture is desirable, but on a welfare basis and not in the hope that it will solve the problems of commercial agriculture, appear several times. Moreover, there seems agreement that a reduction in the number of commercial farmers will not solve the income-price problem of agriculture. While I am generally in agreement with these points, it seems to me that most of those commenting on this point underrated the effect which a labor-scarce situation might have upon farm size, the intensity of farm operations, the price of land, and other aspects of the operations of those farmers who remain.

There was almost complete agreement that dumping of our surpluses abroad will not solve our surplus problem in the future, any more than it has in the past, and that it is in general very bad national policy.

There was also nearly full agreement, as far as one could judge, that the family farm will remain as dominant in the future as it is today, but that it will continue to grow in area, in output, and in specialization.

The foregoing seem to me the major consensuses arising from a reading of this report and the panel discussions; others might well have picked

different points, or grouped these differently—in fact, the Subcommittee in its report did. I think they will give the reader something of the flavor of the studies; but I wish now to supplement them by briefly listing a few of what I consider the major divergent ideas. Consensus is useful and its definition a real contribution. But when, as in this case, one of the chief points of agreement is that we are in a relatively bad way, then it is apparent that more than consensus is needed. The more the discussion veered toward program proposals, the more divergences were apparent. Yet it seems clear that a new approach is needed, since the old one has not worked to anyone's satisfaction, and a new proposal is certainly not part of a consensus. Possibly none of the views yet to be discussed will later prove to have pointed the direction of a new and more workable solution, but at least attention should be called to them as divergences from the herd tendency.

One interesting factual item is in Ruttan's paper: movement of farm people out of an area where there are too many seeking to make a living from agriculture does not alone lead to a sound readjustment of land use and farm operations. Major help for those who remain is needed if a sounder basis of agricultural resource use is to develop.

Ioanes presents a glowing view of agricultural export possibilities—36 per cent in 1965 and 68 per cent in 1975 above the 1950-51—1954-55 level, and in 1975 unsubsidized exports above the heavily subsidized 1956-57 level. Though no one else dealt with this topic as directly, it seems clear that his optimism is not shared by most others, or perhaps by anyone else.

In the general picture of surpluses and excess productive capacity, Murray Benedict differs from many others, it seems to me, at least in the possibility of adjustment with something like the present programs. He stresses the adjustments that have been made in stocks in the past two or three years. He lists circumstances under which the excess capacity might not prove to be serious in the future, and at least suggests that such circumstances have a possibility of realization. In this, he is less pessimistic about future surpluses than are most others, as nearly as one can judge.

There was some disagreement over the acceptability and the probable effectiveness of direct income payments to farmers instead of price supporting measures. Lauren Soth made the most explicit case for direct income payments, though others seemed to endorse them too; W. E. Hamilton of the American Farm Bureau Federation made the most sweeping rejection of them, although it would appear that others opposed them also.

In considering the dilemma of too much production, with its conse-

quent effects upon prices and upon volume in storage, two opposite lines of action were suggested, more or less explicitly. Willard Cochrane most cogently and persuasively states the case for really firm production control—of "bridling the rate of aggregate output expansion through the widespread use and acceptance of production and marketing controls." He feels that this is one of the two major alternatives for escape from the agricultural treadmill of rising output and inelastic demand; the other is widespread business failure and capital losses. Whether one agrees with this proposed solution or not, one must respect the competence with which his analysis is made and presented.

At the other extreme, several writers more or less explicitly endorse the idea of a greater degree of market freedom in price establishment, with either no price supports or supports at a much lower level, and with or without direct income payments to farmers. Chief among these I would place Elmer Working, of the college people, and Warren E. Collins of the American Farm Bureau Federation and Everette B. Harris of the Chicago Mercantile Exchange. They advanced the usual, but to my mind powerful, arguments as to the effectiveness of the free market price system for allocation of resources to different lines of production.

The National Farmers Union, in the person of John Baker, and the National Grange, in the person of Joseph Parker, argued for their respective agricultural programs. Baker would seek to maintain 100 per cent of parity for 100 per cent of each farmer's allotted production, and seek to achieve this through tighter production and marketing control, price supports, direct income payments, and in other ways. Parker argues for a two or three price system, especially for wheat, under which domestic consumption would be at full parity price and other output lower, possibly at world export price. These two papers, incidentally, are more nearly group interest propaganda and less objective presentation of facts and ideas than any of the others. The National Grange's proposal is the object of a considerable part of Helen Farnsworth's analysis, not favorable, as you may guess.

These do not exhaust all the differing viewpoints, of course. They are those which seemed to me most useful to note, within the bounds of length and detail as set by an article of this type. As stated above, where the papers are on different subjects, it is hard in some cases to know exactly how the views of different authors would compare on precisely the same points. Even when there is general agreement, there may well be nuances of meaning and differences of emphasis among authors.

The Probable Results

If this study is as good as I have described it, will it have a significant impact on agricultural policy in the next few years? Much as I would

like to say I think it will, I gravely fear the odds are it will not. Let us see why.

This study was done at the request of a Congressional Committee, and the report and the panel discussions were directed at the Committee. To this extent, the ideas contained in it have more chance of a hearing than if they had been written at the initiative of agricultural economists and directed at each other. But the panel discussions were participated in by only three or four Congressmen. As I have noted above, these are able men, and they seemed to have taken these panel discussions seriously; they may well have added to their already considerable fund of information on the subject. But these men were already familiar, in a general way, with the ideas and facts of the study. One baptizes few converts by preaching only to those already converted. There are over 500 members of both houses of the Congress who did *not* hear the panel discussions, nor, one may guess, read the papers. How much of what is in them will trickle down to the others? How far may the specialized agricultural committees resent the operations of this Subcommittee and be prejudiced against the findings as a result? One can only wonder, but I see no cause for optimism.

How far will this study reach the "general public"? Not at all, in this form. Physically, the report is repulsive to any general reader, as I have noted. The articles are too long, too detailed, and not closely enough oriented to a few central policy issues to hold any readers except specialists in the field. This is not criticism of the report as such and for the purpose it was prepared. But any more general dissemination of these ideas calls for different forums. I do not know if the Subcommittee or its staff has any plans in this direction; I have heard of none. The report could be the basis of a more popular statement. But could it improve on Lauren Soth's already excellent book which, I fear, will have sales of only a few thousand among specialists chiefly? Perhaps writers could be interested in some of the subject matter for a series of feature articles. But the absence of controversy and the effort to achieve balanced statement rob it of interest for many publications.

How far will this report reach even our fellow agricultural economists? Its physical form is against its use even here, and it is true that many of our fellow workers do not look to Congressional documents as sources. This and other reviews in this and other professional journals may help.

But, beyond these essentially procedural matters, there is another and in my opinion more basic reason why this or any other major discussion of agricultural policy may be fruitless at this time. Is the agricultural situation yet ripe for a major reappraisal, agonizing or otherwise? I gravely fear it is not. Although perhaps no one is satisfied with the present agricultural program, yet there are many entrenched interests in its pres-

ervation; change is always difficult, and requires power to overcome inertia as well as opposition. Any major change in agricultural programs will leave some groups of producers, some regions, or some individuals worse off than now; thus, they will oppose change of any kind. Moreover, there are public employees and interest group employees and representatives with vested interests in the present programs.

To add to this, the old Farm Bloc is now badly split. Concerted action is difficult or nearly impossible, and any program which made major changes could not but split it still further. The farm organizations face varying views within their ranks. I cannot see any effective new agricultural program arising at this time from within the specialized agricultural interest groups. Any changes will be the smallest possible, and even these will have a hard time getting accepted.

Certainly the actions of Congress since this report was published do not afford grounds for optimism for basic changes in agricultural programs.

Although the costs of the farm program are high and the nonfarm segment of society is beginning to grumble more loudly, I see no signs yet of a real revolt. Nonfarm groups and nonfarm Congressmen have their own special interests and problems, with little time or attention to give to agriculture, and with some fear of arousing resentment that might react adversely to their own interests. As of now, it is hard to see the drive necessary for change coming from this group either.

Of course, all this may change, if or when costs of the agricultural program have risen further and surpluses are even larger. In 1933, there was no argument that a new farm program was needed and would be adopted; the only questions were as to its form. In 1940, we were headed for a major showdown on agricultural policy, but the war intervened and made past mistakes seem like statesmanship. Now there is much grumbling, but it is not really serious enough to produce basic change, I fear.

A new administration, whether it comes to power in 1960 or in 1964 or some other year, will have to pretend it has a new farm program, as the present administration did when it came to power. But will it be really new? And, if new, better or worse than the present one? In Benson's defense, one can say some of his critics have even worse ideas than he.

In the meantime, surplus farmers are moving off farms, commercial farmers are increasing output, and other changes in agriculture are occurring; somehow, life must go on, even in a relatively depressed industry, regardless of government programs or lack of them.

Anyway, regardless of the effect of this study, it is a most excellent piece of work, worthy of the careful attention of agricultural economists.

THE FARM POLICY DILEMMA

WALTER W. WILCOX
Library of Congress

FARM income is low today—using any modern yardstick one may choose.

Farm operator families on the 2,213,000 commercial (high production) farms received an average income of $5,415 in 1956 while all nonfarm families, including those living on skid row and public relief programs, received an average income of $6,900. The realized returns to all farm labor and management was only 69 cents an hour in 1957 while workers in manufacturing industries received $2.07 an hour.[1]

Farm income would be even lower except for the price-supporting activities of the federal government.

A rough and incomplete appraisal indicates government price-support and related programs, on a year-by-year basis, must have raised total net farm income substantially above what it otherwise would have been each year in the late 1930's and early 1940's, in 1948 and 1949, and from 1952 to date.

This rough approximation of the income effects of price supports takes account of the direct government payments and the removal of supplies from commercial markets by the price supporting programs. Supplies were removed from commercial markets by surplus removal purchases using Section 32 funds, and by the net annual increases in CCC loans and inventories in these years. It is assumed that each $1 of aggregate farm output removed from commercial markets by these programs increased farm income $2.50—or that the price elasticity of aggregate output was approximately -0.4.[2]

This estimate fails to take account of the income effects of acreage allotments in holding down aggregate output on a year-by-year basis of cotton, wheat, tobacco and several other crops. It fails to include the income gains which resulted from a shift in productive resources from crops having a highly inelastic demand such as wheat and tobacco to other products having a less inelastic demand such as soybeans, feed grains and livestock. It also fails to take account of the dynamic effects

[1] Interest at a rate of 4¾ per cent was allowed on the current value of farm real estate, machinery, equipment and farm working capital by the AMS in estimating the returns per hour to farm labor. See the statements on farm income comparisons by Koffsky, Grove and Johnson in *Policy for Commercial Agriculture;* Papers submitted by Panelists, Joint Committee Print, Joint Economic Committee, U.S. Congress, November 1957, pp. 79-90 and 453.

[2] Wheat, cotton, corn and dairy products made up most of the farm output removed from commercial channels. The short run price elasticities of these products are about as follows: wheat–0.3, cotton–0.5, corn–0.5, milk used for manufacturing–0.4.

of the higher and more stable farm income in the earlier years on the level of farm output and prices in later years.

This rough, incomplete measurement indicates that in the absence of price supporting programs realized net farm income on a year-by-year basis would have been 20 to 55 per cent lower in the years 1937-39, 14 to 43 per cent lower in 1940-42, 24 to 34 per cent lower in 1948-49, and 28 per cent or more lower 1952 to date (Table 1).[3]

TABLE 1. SELECTED PRICE SUPPORT ACTIVITIES AND REALIZED NET FARM INCOME, 1937–56[1]

Calendar year	Section 32 purchases	Increase in C.C.C. loans and inventories	Columns 1 & 2×2.5[2]	Government payments	Rough estimate: Contribution of price support activities (Total columns 3 & 4)	Realized net farm income	Contribution of price support activities as percentage of net farm income (Column 5÷6)
	Millions	Millions	Millions	Millions	Millions	Millions	
1937	$ 35.2	$ 241.1	$ 690.7	$367	$1,057.7	$ 5,232	20
1938	211.6	523.5	1,837.7	482	2,319.7	4,273	55
1939	143.9	105.4	623.2	763	1,386.2	4,394	32
1940	226.1	215.9	1,105.0	723	1,828.0	4,289	43
1941	196.3	−71.6	311.7	544	855.7	6,153	14
1942	112.0	261.	932.5	650	1,582.5	8,825	18
1943	63.4	−77.8	−36.0	645	609.0	11,875	5
1944	24.9	−88.1	−158.0	776	618.0	12,217	5
1945	19.2	−692.3	−1,682.7	742	940.7	12,850	−7
1946	78.4	−38.9	98.7	772	870.7	15,000	6
1947	51.2	−120.5	−173.2	314	140.8	17,191	1
1948	75.6	2,013.1	5,221.7	257	5,478.7	15,943	34
1949	96.6	1,161.6	3,145.5	186	3,331.5	13,673	24
1950	46.0	−1,718.6	−4,181.5	283	−3,898.5	12,857	−30
1951	37.5	−339.9	−756.0	285	−471.8	14,802	−3
1952	82.3	1,674.1[3]	4,391.0	275	4,666.0	14,256	33
1953	177.6	2,505.6[3]	6,708.0	213	6,921.0	13,880	50
1954	58.9	1,205.0[3]	3,159.7	257	3,416.7	12,190	28
1955	179.1	1,763.7[3]	4,857.0	229	5,086.0	11,581	44
1956	171.1	1, 25.7[3]	3,242.0	554	3,796.0	12,070	31

[1] See preceding text and footnote [2] with respect to limitations of these data as an accurate measure of the economic effect of price support activities. Section 32 purchases and increase in CCC loans and inventories on fiscal year basis lagged six months in relation to farm income and Government payments. Section 32 purchases taken from U.S.D.A. *Realized Cost of Programs Primarily for Stabilization of Farm Prices and Income*, In 83d Congress, 2d session, Senate. Farm Program. Hearings before Committee on Agriculture & Forestry. Part 1, January 17 and 22, 1958. Washington, U. S. Government Printing Office, 1958, p. 42. Net increase in CCC loans and purchases computed from U.S.D.A. *Commodity Credit Corporation Charts*. Washington, D. C., November 1957. Tables 5A, 6A and 6B. Government payments and realized net farm income taken from U.S.D.A. *Agricultural Statistics 1956*, and *Agricultural Statistics, 1942*. Washington, U. S. Government Printing Office, 1957 & 1943. pp. 470 and 660.

[2] The sum of columns 1 and 2 are multiplied by 2.5 since statistical analyses indicate that farm income is increased about $2.50 for each $1 reduction in farm products supplied to commercial markets when farm products are in ample supply. (See previous footnote [2].)

[3] Net removal of farm commodities from commercial markets by CCC operations. (Source: computed from U.S.D.A. data.)

In the longer run, the public as well as farmers appear to have reaped net benefits from farm price programs—benefits which are substantially the same as those realized from research and educational programs. Consider these facts, for example: In the 19 years preceding the adoption of farm price support and related adjustment programs, farm output in-

[3] A more accurate evaluation of the economic effects of these programs is highly desirable. Plans are under way to have the U.S.D.A. regularly report the relevant data on net physical quantities of each commodity removed from commercial markets by price support operations. With such data a more precise evaluation of the impact of farm price support programs on farm income should be possible.

creased 6 per cent. In the 20 years of farm price support programs (excluding the war years 1941-45), farm output increased 40 per cent. As a specific example of the influence of farm price support programs, Gray, Sorenson and Cochrane found that potato production was higher and prices were lower when price supports were in effect in the late 1940's than would have been expected under free market conditions.[4]

Many factors have contributed to the rapid increase in output in recent years. One of the factors has been the increased stability and higher level of farm income resulting from farm price support programs in the past 25 years.

Largely because farmers have been unable or unwilling to balance output with available markets, their income gains from price support programs have resulted in gains for other sectors of the economy. These gains are of two types—additional workers released by investment in labor saving machinery and increased output of food and fiber in subsequent years.

It is highly probable that the aggregate influence of increased stability, and the higher level of farm income resulting from price support programs has accelerated technological progress and increased efficiency in agriculture, more than offsetting the inefficiencies in resource use caused by specific commodity programs. As evidence in support of this, Dr. Barton's studies indicate that farm output per unit of total resources used *has been increasing twice as rapidly in the past 25 years as in the 20 years 1910 to 1930.*[5] Surely the inefficiencies in resource use introduced by acreage allotment programs must have been more than offset by the income effects of the price support programs to permit such a record.

Agricultural economists have sometimes assumed that the improved income position of agriculture has slowed down desirable migration out of farming. However, Professor Bishop has found that this is not true. Price support programs have not retarded the migration of workers out of agriculture.[6] This is not surprising since the income position of farm people has continued to be less satisfactory than that of nonfarm people in spite of the improvement resulting from price support activities.

Probably somewhat the reverse influence has prevailed. Farm enlargement and farm consolidation must have been facilitated by the increased stability and higher short-run level of farm income resulting from price support programs. Also, stable or rising land prices, in part the result of these programs, have permitted farmers to leave farming without capital losses. This is an important aid to outmigration.

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[4] Minnesota Agricultural Experiment Station Bulletin 424, 1954.
[5] See Joint Committee Print (footnote 1), p. 22.
[6] *Ibid.*, pp. 437-447.

This brief summary of the effect of past price support programs is in no sense intended to be a defense of the status quo. Existing price support activities have been in urgent need of modernization for the past 10 years. Yet in view of these past accomplishments, it is surprising that agriculture's spokesman in the cabinet, his research staff, and agricultural economists generally have been silent with respect to these facts while publicizing the government costs of farm price support programs. Intelligent plans cannot be made for the future by those who only see the past through jaundiced eyes.

Production Trends

Although realized net farm income dropped 19 per cent in the five-year period 1952-57, total inputs used in agricultural production have increased slightly. A 12 per cent decline in number of farm workers[7] was fully offset by increases in other inputs.

It is of interest to observe that since World War II, the dynamic effect of labor leaving agriculture probably has been output-increasing. Labor leaving a continuing commercial farm enterprise often is replaced by modern mechanical equipment which results in improved technical production practices and always requires amortization, hence puts pressure on the family to increase output. If it is a son or daughter of the farm family itself who leaves, the young migrant may require financing for a period until he finishes an educational or training program. This additional financial burden also stimulates efforts to increase output and income on the home farm. When land is released by established farm operators leaving agriculture, on balance it probably goes to more efficient producers. Given the present labor supply and improved technology available for use in agriculture, similar influences are expected to continue dominant for at least another five or 10 years.

On the basis of these facts and others which are commonly known, it seems probable that farm output in the next 10 years or so will continue to increase as fast or faster than population increases.[8] This of course will be merely a continuation of the situation which has existed in the recent past. Furthermore, it seems probable that output will continue to be excessive in relation to market outlets even though farm prices drop further. (It is highly probable that additional capital will be channeled into agriculture by processors and production supply companies as vertical integration in agriculture increases.)

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[7] Based on the U.S.D.A. farm labor series. The decline was only 8 per cent in the commerce farm labor series.

[8] See, for example, *American Agriculture in 1965*, by James T. Bonnen, Joint Economic Committee Print (footnote 1), pp. 145-156.

Market Expansion Potentials

"Market expansion" at lower price levels and "learning to live with abundance" are phrases or slogans which have appeared with increasing frequency in recent months in public statements relating to agriculture. The probable economic results of such policies have been made to appear highly attractive. Yet data published in the *Marketing and Transportation Situation,* an official publication of the Department of Agriculture, testify to the ineffectiveness of such policies in the past five years.

Consider these facts with respect to the recent past:

Nine per cent more American consumers, with 10 per cent higher per capita real incomes in 1957, bought 11 per cent more food from farmers on a value weighted basis, including more high-cost animal products relative to cereals and potatoes than in 1952. Yet in 1957 farmers were paid only $19.5 billion for this food—$600 million less than they were paid for the smaller quantity containing fewer livestock products in 1952. This is an indication of the lack of effectiveness of market expansion in recent years in conjunction with "living with abundance" in commercial markets.

This experience may be stated in another way. Although farmers' production expenses were $416 million higher in 1957 than in 1952, and consumers' disposable income was $63.2 billion higher, farmers received fewer dollars for their 11 per cent larger food deliveries last year because of the abundance of farm products in the market places. These are the economic consequences of "abundance" even though the advertising and promotional efforts of both the producers and food trade were at record levels in 1957.

In view of this record, how can so many people in such important positions place such great confidence in market expansion as a method of increasing farm income at this time? Market expansion is a long-run, not a short-run solution to the farm problem. And farm output or market supplies must be brought more nearly into balance with market outlets at current prices before the modest accomplishments of our greatest market expansion efforts will show satisfactory results.

Rising Land Values No Indication of Economic Health

Farm real estate values have risen sharply since 1947-49. A part of this increase was a return to more normal, long-run relationships between farm land values and farm income. Increases in land values since 1952, however, in an important respect are an indication of maladjustments in agriculture. They cannot be considered a sign of economic health as has been suggested in recent months. Rather, in large areas they reflect economic pressure for farm enlargement and the difficulty people have in finding a satisfactory substitute for farming as an occupation.

Farmers buy about two-thirds of the farm land that is sold each year. The competition for additional land for farm enlargement together with the other demands for agricultural land has resulted in farm operators receiving very low returns for their management and labor (Table 2).

TABLE 2. INDEXES OF FARM REAL ESTATE VALUES, RETURNS PER HOUR OF FARM LABOR AND HOURLY EARNINGS OF MANUFACTURING EMPLOYEES, 1952–57 [1947–49=100]

Year	Farm real estate values per acre	Realized return per hour to all farm labor and management[1]	Hourly earnings of mfg. employees
1952	132	92	126
1953	132	90	133
1954	128	81	136
1955	133	75	141
1956	138	82	149
1957	147	77	156

[1] After allowance for interest at 4¾ per cent on capital investment. Agricultural Marketing Service, U.S.D.A.

Although recent increases in farm land values are the result of many factors, it is not a healthy situation to find land values and wages of industrial workers rising while returns to farm labor are falling. This is especially true when the returns to farm labor were already less than half the wages received by industrial workers. As indicated in the opening paragraph, returns to all farm labor and management in 1957 fell to 69 cents an hour. This was only one-third the hourly earnings of manufacturing employees.

Income Losses Not Offset by Fewer Farmers

Although livestock producers are enjoying satisfactory incomes in 1958, it appears probable that feed grain and livestock producers will suffer the greatest income losses in the next few years. There are several reasons for this: Feed grain stocks have been accumulating for five years under the price support program which has indirectly supported livestock prices and incomes. These stocks cannot be diverted to foreign countries to the same extent that it is possible to divert wheat and cotton stocks. Increased quantities of wheat will be offered for feed under freer market conditions largely offsetting such reductions in feed production as may occur as the result of increasing cotton and wheat acreage allotments. Further, substantial increases in the output of livestock products per unit of feed consumption are probable, especially in hog production.

Movement of people out of agriculture and farm consolidation has been advocated as a means of maintaining farm family incomes at a satisfactory level even though total net farm income falls. Between 1947 and 1956 the number of farms in the United States declined 1.7 per cent per year. The total farm population also has been declining at the rate of 1.5 to 2 per

cent a year in recent years. Much of this movement of people to nonfarm jobs has been people leaving low-income farms which produce very few products for sale as well as people leaving commercial farms.

Some people suggest that public programs should be undertaken to speed up these trends. Even though the current recession were short-lived, it is doubtful that measures to speed up these movements will receive public support in view of the community adjustment problems growing out of the current rate of farm consolidation and migration of people from farms. The rate of movement of people out of agriculture in the next five to 10 years will depend primarily on the rate at which new job opportunities open up.

If one can depend on a continuation of production trends and the results of recent statistical analyses of supplies and prices, there is little likelihood of sufficient farm consolidation or movement of people off commercial farms to maintain current income levels on a per family or per capita basis if free market conditions prevail in the next five to 10 years.

As will be elaborated in subsequent paragraphs, a decline in net farm income of 25 to 40 per cent is in prospect under free market conditions in the years immediately ahead. Farm people may either consciously choose to return to free markets, or because of a failure to agree on other courses of action, they may allow free market forces to operate again. If this occurs, the expected fall in total income, because of farmers' lack of bargaining power, will be softened somewhat by increased off-farm work of family members. The drop in income also will be mitigated by an annual reduction of perhaps 2 per cent a year in the number of farms and the number of farm people sharing the income. But the expected drop in income is not likely to be fully offset by the fewer people in agriculture within the next five to 10 years.

The Alternatives

It is against this background that one must consider agriculture's possible courses of action in the next five or 10 years. Agriculture has a choice among three relatively unattractive courses of action, or some combination of them.

(1) It may continue the current supplementary distribution programs at home and abroad at the same or at a somewhat higher level than they have been operating during the past three years. This is roughly $1 to $2 billion a year in terms of values at the farm. These programs have made little progress in reducing aggregate stocks. Reductions in dairy products, cotton and wheat have been largely offset by increased stocks of feed grains. A continuation of these distribution programs at recent or at a somewhat higher level at best would merely maintain farm income at

current levels in an otherwise rapidly expanding economy. However, it is doubtful that current acreage allotments have a significant effect on total farm output other than changing its content somewhat, hence are not essential to the success of this course of action. Their continuation, however, may be essential for the maintenance of the incomes of the producers of the restricted crops which have a highly inelastic demand.

(2) A second course would be to develop effective aggregate production controls which hold production 4 to 6 per cent below what it otherwise would be year after year for at least five to 10 years, again merely to maintain farm income at current levels, or

(3) Allow all production to move through commercial markets and accept a drop of $2 to $5 billion or 25 to 40 per cent in net farm income as compared with 1956-57.[9]

If net farm income falls only 25 to 40 per cent from current levels, it is doubtful that the adverse effects on the supply function would be sufficient to bring output into balance with market outlets except at prices 10 per cent or more below 1956-57 levels. Under free market conditions, output might well continue to be 2 to 4 per cent in excess of the amount needed to supply available markets at stable prices, forcing farm prices down 10 per cent or more. Production costs now take about 65 per cent of the gross farm income. Under these conditions, a 10.5 per cent reduction in farm prices would result in a 30 per cent reduction in net farm income.

Concluding Observations

Adequate income is one of the prerequisites for a good farm life. However, farm families have many goals in addition to monetary income. They desire freedom to make their own decisions. They desire the respect and approval of their urban acquaintances.

In our democracy farm families themselves have the opportunity to choose among many conflicting goals. The role of the expert (social scientist) and an important part of the complex role of the farm leader is that of supplying farm people with relevant facts and analyses as a basis for intelligent policy choices in line with their value systems.

It is inevitable that there is much confusion in this field. But the confusion has been confounded in recent years by a failure on the part of many in leadership positions (including some with advanced degrees) to dis-

[9] A fourth course would be to make up the difference by direct government payments between family incomes received from prices in the market place and some agreed desirable level of family income.

This course of action appears to be sufficiently improbable to warrant placing it in a footnote. However, proposals for individual commodity programs involving a combination of government payments making up the difference between market prices and an announced support level on domestic allotments, with free market prices on the balance of the production already has substantial legislative support.

tinguish between facts and values. Consciously or unconsciously they have ignored facts which did not fit in with their value systems. Consciously or unconsciously they have discouraged research which might develop findings not in accord with their value systems. In the arena of public discussion there has been no distinction on the part of many leaders between an intelligent interpretation of social scientists' findings and statements calculated to mold the value systems of farm people into particular patterns.

It is easy to understand the failure of farm leaders to distinguish between educational activities based on research results and an attempt to mold the value systems of farm people in patterns similar to theirs. It is more difficult to understand the great dearth of comprehensive analyses on which to base intelligent policy decisions. Surely the scarcity of relevant comprehensive analyses is not due to a lack of social scientists with advanced degrees in high administrative and advisory posts, or to a shortage of well-trained social scientists.

In any event this analysis is designed to add to the body of relevant facts which are so urgently needed and it is hoped that it will move the "great debate" forward to a higher, at least to a more factual level.

AN ECONOMIC APPRAISAL OF CHANGES IN RURAL FOOD CONSUMPTION

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A REVIEW of changes in rural food consumption and analysis of their economic implications leads to the conclusion that a new dimension must be added to work on projections of demand for farm food commodities. New data and analyses using 1955 household survey data and time series measuring food disappearance and several economic and social factors point up the need for projections in terms of purchased foods only. Such projections indicate the prospective demands for food *sold* by farmers and for food marketing services. Hitherto, projections of United States demand for farm commodities have been developed in terms of consumption of food *from all sources*. The difference between these two approaches arises from the changing significance of consumption of food from supplies produced for home use, practically all by the rural population.[1]

Preliminary findings of an analysis—based on (a) Rex F. Daly's economic framework;[2] (b) historical changes in consumption of purchased foods by the urban, rural nonfarm, and farm populations; and (c) estimates of changes in urbanization and extent of home food production by 1975—indicate that the demand for commercially produced and marketed farm foods may increase 16 to 18 per cent per capita from 1955 to 1975, measured at the farm level. This is consistent with Daly's projection of a 10 per cent increase in per capita consumption of farm foods from both commercial production and production for home use. But demand projections for commercially handled foods are more pertinent to study of the future role of American agriculture.

The basic data and analyses backing up these conclusions and a number of significant findings regarding economic implications of changes in rural food use are developed in this article in five parts.

(1) A variety of measures is used to trace changes in rural food consumption between 1942 and 1955.

(2) The factors contributing to changes in rural food consumption and

[1] The urban category of the 1955 Survey of Household Food Consumption covers the housekeeping population living in communities of 2,500 population or more and in the suburbs of large cities. The rural population includes people in rural nonfarm and farm households. Rural nonfarm households are those outside urban areas and not operating a farm. Farm households include only those operating a farm.

[2] Daly, Rex F. "Projections of United States Demand for Food and Fiber in 1975." Paper submitted for hearings on Policy for Commercial Agriculture, Joint Economic Committee of the Congress, November 22, 1957.

food purchases are delineated and their effects measured.

(3) The impacts on the U. S. commercial food market of changes in major economic and social factors affecting the rural sector are measured for the period 1942 to 1955.

(4) Use of data and analyses developed in preceding sections, Daly's economic framework, and specially developed income-size and urbanization distributions for 1975, permits an evaluation of the potential changes in the U. S. commercial food market and in demand for commercially produced farm foods which may come from future changes in rural food consumption.

(5) The last section of the article contains measures of the relative significance of the rural food market in 1942, 1955, and prospects for 1975 as well as some discussion of the significance of these findings for U. S. demand analysis.

Changes in Rural Food Consumption, 1942 to 1955

Data on household food use such as those in Reports No. 1-5 of the 1955 Survey of Household Food Consumption[3] provide the wherewithal for a fairly accurate description of many aspects of food consumption. There are matching sets of figures on the market value of all food consumed, of food and beverages eaten away from home, and of food at home–subdivided into purchased supplies, home-produced food and other food obtained without direct expense. The data include information on quantities and values of about 230 food commodities used. Comparison of data for rural nonfarm and farm households in a week of spring 1955 with matching data for spring 1942 from the *Study of Family Spending and Saving in Wartime*[4] provides a variety of measures of how rural food consumption patterns have changed and valuable clues to the whys.

For this analysis, the average market value of all food consumed per person and average disposable income per person were derived from published household averages from the two surveys for households grouped by urbanization and by income. The market value of food in spring 1942

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[3] U. S. Department of Agriculture, *Food Consumption of Households in the United States, Northeast, North Central Region, South,* and *West.* Survey Reports No. 1-5. Washington, D.C. 1956.

An article describing the survey data, notes on procedures for working with them, and examples of their use in agricultural economic problems was published in *Agricultural Economics Research,* July 1958.

[4] Data on food consumption at home were published in Misc. Pub. No. 550 *Family Food Consumption in the United States,* U. S. Department of Agriculture, 1944. Rural income and expenditure data are found in Misc. Pub. No. 520 *Rural Family Spending and Saving in Wartime,* U. S. Department of Agriculture, 1943. Other data for all urbanization categories and for urban only were published in Bul. No. 822 *Family Spending and Saving in Wartime,* U. S. Department of Labor, 1945.

and income data for the first quarter of 1942 were converted to the price levels of the 1955 survey data, using the BLS Index of Retail Food Prices and the BLS Consumer Price Index. The same adjustments were made in unpublished 1942 survey data on expenditures for food purchased in the week for consumption at home, supplied by the Institute of Home Economics, Agricultural Research Service.

Information on the structure of food consumption in spring 1942 appears to be generally usable for comparison with 1955 survey data. ("Structure of food consumption" in this article refers to the whole configuration of rates of consumption from all sources and from purchased supplies only among households grouped by urbanization and by income.) However, the consumption of some items in spring 1942 was affected by the collection of data in April and May only and of other items by wartime food developments. Detailed analysis of commodity data indicates that the seasonal differences were not major and were offsetting.

The effect of wartime food shortages on food consumption and food purchases for consumption at home by the rural population cannot be measured directly with available data. The per person averages for consumption at home for meat and sugar in particular appear to be low in relation to AMS data on disappearance, but comparisons of the averages for each income class in the three urbanization categories with such data from the 1955 survey reveal a high degree of internal consistency.[5] The short food supplies for consumption at home in spring 1942 appear to have been shared quite generally by rich and poor, farm and nonfarm people. Evidence from other household surveys more limited in coverage and other information which will be considered in this article support the argument that there have been basic changes in rural food consumption in the last two decades, not just a recovery from a low wartime level.

The only measure of the over-all level of food consumption obtainable

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[5] The survey average for meat consumption per person at home in April-May 1942 was 15 to 20 per cent lower than the AMS estimate of apparent meat disappearance in that period into all civilian distribution channels for consumption in homes, eating places, and institutions (including admittedly rough quarterly data on farm home consumption.) The possibility that the survey data on consumption at home were under-reported is lessened by facts that the 1942 "Engel curves" for beef and pork for households in each urbanization have generally the same slopes and shapes as their counterparts in 1955 though at different levels, and that the urban "Engel curves" for all meats in 1942 and 1948 are very close in slope and in level. Some error is also quite possible in the estimate of civilian meat disappearance in April-June 1942. Furthermore, commercial meat supplies distributed in spring 1942 for consumption at home were probably reduced by greatly increased sales through eating places and perhaps by unreported changes in stocks.

The term "Engel curves" refers to the graphic relationships obtained by plotting, preferably on logarithmic paper, the averages for all foods or individual foods per person for each income class against average disposable money income for households in each urbanization, as in the charts for this article.

directly from household food surveys is the market value of all food at home and away (called money value, from which approximate retail equivalent values can be estimated, however).[6] According to the market value gauge, both farm and rural nonfarm families increased their use of food at home and away from home from about $5.50 per person (at 1955 prices) in a week of spring 1942 to $7.10 for farm and $7.50 for rural nonfarm in spring 1955. The farm Engel curve for 1955 was much less elastic below the $2,000 family income point (in 1955 dollars) but varied little in higher income levels from that of 1942. Graphic analysis shows that the Engel curve for rural nonfarm households was 10 to 15 per cent higher in 1955 than in 1942 and became slightly less elastic.

Data on *food expenditures at home and away from home* are particularly significant for analysis of changes in the commercial food market.[7] In these terms, farm food outlays rose from a $2.23 average in spring 1942 to $4.22 in 1955, and rural nonfarm from $4.43 to $6.70. The Engel curve for farm households was slightly less elastic in 1955 and at a substantially higher level. (Figure 1) The rural nonfarm curve was also slightly less elastic, but the percentage change in its level was less (Figure 2).

Consideration of the components of these changes in over-all patterns of rural food consumption is a first step toward identification of factors causing them. First, average outlays for food away from home tripled, in constant dollars. The increase was somewhat greater for families below median income. Increases in away-from-home food expenditures accounted for one-fourth of the increase in total food expenditures per person by rural nonfarm and farm households from spring 1942 to spring 1955. This change is readily explained by changes in the ways rural people live. More children buy hot lunches at school. Family members work away from home or go to town for other reasons more often and carry their meals from home less frequently.

Second, expenditures for food used at home by farm and rural nonfarm households rose significantly more from 1942 to 1955 than did market value

[6] Three new indexes to measure the structure of food consumption are now being developed in terms of (1) all farm food commodities, (2) purchases of farm foods, and (3) the value of over-all consumption in terms of retail store prices in 1947-49. Each index will relate the per person food consumption rates of households in the 1955 food survey in each income class of each urbanization category to the U. S. average (equal to 100) and the averages for each urbanization category of each region to the all U. S. average. These structural indexes will be comparable in definition and price weights with the time-series index of per capita food use of farm food commodities (farm level—with a separate index for purchased foods only) and the index of per capita food consumption (retail level).

[7] The only segments of the commercial food market not covered by household survey data on food expenditures are the sales of food to institutions and the nonhousekeeping population and sales of meals, snacks and beverages by eating places to the nonhousekeeping population. The housekeeping population in spring 1955 included about 153 million people and excluded a little over 9 million.

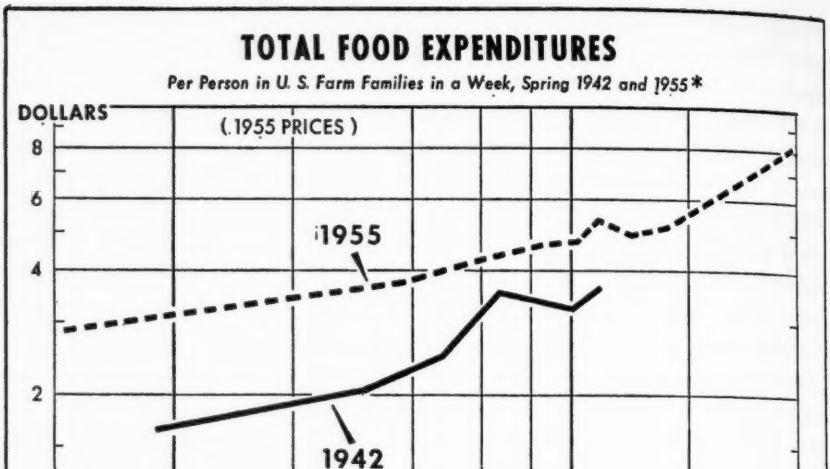

FIG. 1. FARM

FIG. 2. RURAL NONFARM

of all foods at home (which includes food obtained without direct expense –such as home produced), as the following tabulation indicates:[8] The im-

		In a week, spring		
		1942	*1955*	*Increase*
Market value of food at home, per person	U. S.—all	$6.24	$7.01	$0.77
	Rural nonfarm	5.18	6.51	1.33
	Farm	5.45	6.57	1.12
Expenditures for food at home, per person	U. S.—all	5.22	6.27	1.05
	Rural nonfarm	4.08	5.71	1.63
	Farm	2.10	3.69	1.59
Expenditures as percentage of market value of all food	U. S.—all	84%	89%	
	Rural nonfarm	79	88	
	Farm	39	56	

portant element in this change was the reduction in home production of food. The farm average for home production dropped from 61 to 41 per cent of the market value of all food at home and the rural nonfarm average from 22 to 8 per cent.

The farm pattern of home production in relation to income level changed from a slight increase with income in dollar value of home production to one of little variation with income in 1955. The most significant facts about changes in home production by farm households are the substantial increase in home-produced beef and pork and the decrease in both the average quantity of other foods home-produced and in their relation to total food consumed per person by farm households. (Figure 3)

As Figure 4 shows, the 1955 relationship between home food production and income of rural nonfarm households decreased much more consistently than in 1942.[9]

At this point a few comments on the *direction of changes in rural food patterns* may be helpful. Rural families are eating more like urban ones. The rural average for market value of food at home changed from 78

[8] Admittedly, the comparison of over-all dollar measures of food consumed at home is not as precise as the use of unrounded data appears to indicate because of reliance on BLS food price index which was having trouble keeping up with the price situation in spring 1942. The reliability of the BLS and BAE price indexes at that time was the subject of several extensive investigations. Unrounded data are used here in lieu of following through the burdensome process of checking and balancing the roundings. These averages are for all households, including singles.

Data on food expenditures for spring 1942 pertain to actual dollar outlays whereas those for spring 1955 represent the money value of purchased food actually *used*. The difference is only fractional, but it explains why the percentage of market value home produced by rural nonfarm households plus the expenditure percentage can total 101 per cent without a 1 or 2 per cent allowance for value of food received as gift or pay.

[9] The slightly earlier period in 1942 than in 1955 probably reduced the rate of use of fresh garden produce but increased the rate for home-canned and stored vegetables and fruits.

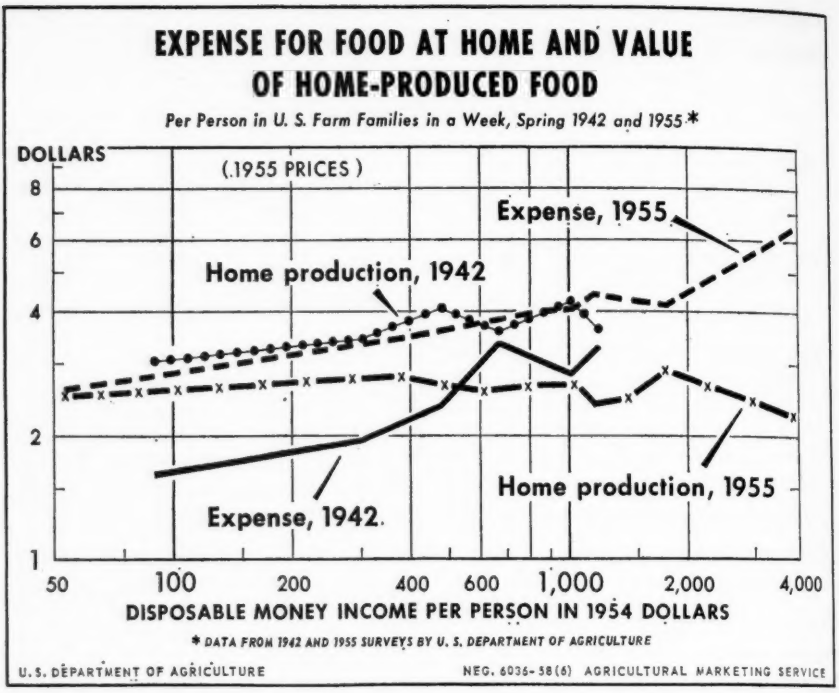

FIG. 3. FARM

per cent of the urban average in spring 1942 to 88 per cent in 1955. Food expenditures have changed even more. The increasing closeness of urban and farm average consumption rates for individual commodities (to use the two extremes) resulted partly from changes in income distribution and partly from much higher expenditures by farm households at all levels of income. The decreased elasticity of farm and rural nonfarm Engel curves of the relation of food consumed to income has resulted from flattening below the median and merits special attention later in this article.

Factors Contributing to Changes in Rural Food Consumption

Wartime food shortages in spring 1942 may have contributed somewhat to the magnitude of changes in rural food consumption and food purchases. Detailed examination of commodity data from the 1942 and 1955 surveys showed that much of the change in the Engel curves for all food for households in the three urbanization categories came from changes in poultry and meat. The great development of the broiler industry ties in with the poultry changes. For meat, the similarity of the 1948 urban Engel curve in slope and level to that of 1942 seems to indicate that the meat situation for urban households in spring 1942 was not far out of line.

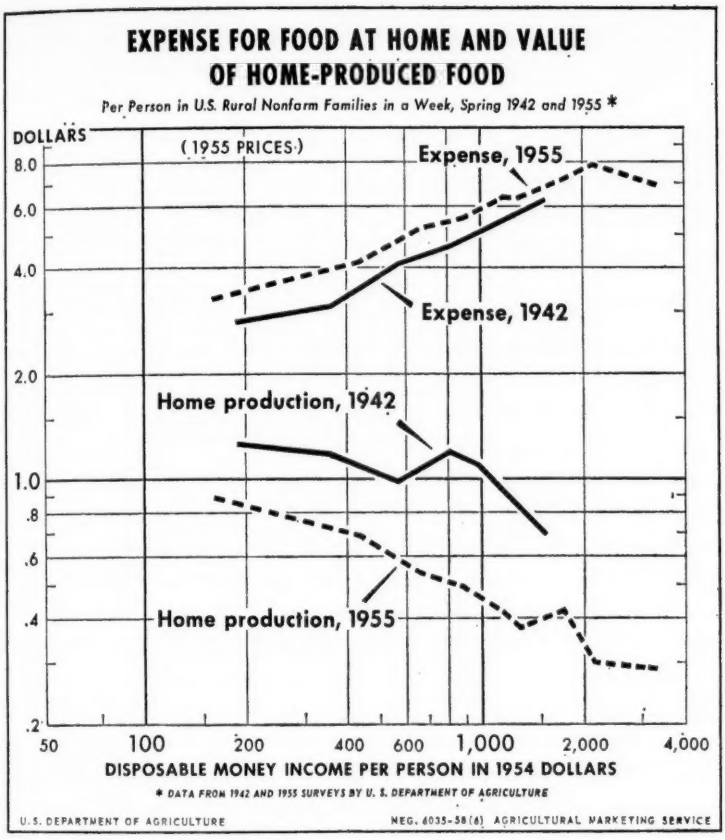

FIG. 4. RURAL NONFARM

If commercial meat supplies were available for urban households, rural people could have bought them if they wished and if they had the necessary purchasing power. Therefore, we may conclude that the changes in rural meat consumption from 1942 to 1955 reflect basic changes in ways of living and eating, which will be considered shortly, not just a recovery from a temporary situation.

Changes in Urbanization

Changes in the distribution of the housekeeping population among the three urbanization categories materially affected the all U. S. averages for several measures of food consumption. The following distributions for the participating housekeeping population in spring 1942 and 1955 show that the net effect was a shift from the farm to the rural nonfarm category. (Details are given for research use.)

	Percentage of housekeeping population, by urbanization		
	Urban	*Rural nonfarm*	*Farm*
In all households			
Spring 1942	57.9	21.9	20.2
Spring 1955*	59.2	27.9	12.9
In households of two or more persons, spring 1955	58.9	28.6	12.5

* One person households not subdivided by income.

Higher Incomes

Higher real incomes caused about half of the increase in average food consumption by rural families from spring 1942 to 1955, as measured by the market value of all food consumed, but they were a relatively less significant factor in increased *food expenditures* by farm families than for rural nonfarm families. Measures of the extent to which changes in income-size distribution (in constant dollars)[10] could explain changes in the averages for a number of value measures of over-all food consumption and quantities of major foods consumed per person from spring 1942 to spring 1955 are summarized in Table 1. Differences in slope and level of the Engel curves for 1942 and 1955 cause the variations between the two sets of data measuring income effect reported in the table. For example, the drop in the whole level of the home-production curve in Figure 4 explains why the combination of 1942 averages and 1954 income-size distribution could account for only 11 per cent of the decline from $1.13 per person of home-produced food in rural nonfarm households in a week of spring 1942 to 50 cents in 1955. The greater extent and slope of the 1955 Engel curve and its lower level apparently contribute to the fact that 71 per cent of the decline in home production is explained by the measure using 1955 averages and 1942 income distribution.

Changes in Income-Food Relationships

Other economic and social factors bearing on changes in rural food consumption primarily affected the Engel curves, which trace the relationships of value and quantity measures of food use to average dispos-

[10] The term "income-size distribution" refers to distribution of the population among groups or classes based on size of their disposable money income per family. It is frequently shortened to "income distribution." The distribution of the housekeeping population in the first quarter 1942 in terms of current-dollar-income was converted to a distribution at the 1954 price level. This was done by plotting the cumulative frequency of the percentages in each income class on semilogarithmic paper (percentages on vertical, income on logarithmic horizontal scale), then shifting the entire curve to the right by the percentage change in the Consumer Price Index from January-March 1942 to 1954, then reading the new percentages for each income class from the vertical scale.

TABLE 1. PROPORTION OF CHANGE IN SELECTED ITEM AVERAGE PER PERSON FROM SPRING 1942 TO SPRING 1955 EXPLAINED BY CHANGES IN INCOME-SIZE DISTRIBUTION OF THE RURAL POPULATION[1]

Item	Rural nonfarm		Farm	
	1942 averages and 1954 income[2]	1955 averages and 1942 income[3]	1942 averages and 1954 income[2]	1955 averages and 1942 income[3]
	Per cent	*Per cent*	*Per cent*	*Per cent*
A. Value measures of food consumption (increases)				
1. Total market value of food at home and away	46	51	55	51
2. Total expenditures for food at home and away	47	51	27	35
3. Expenditures for food away from home	31	45	16	50
4. Market value of food at home	53	54	68	56
5. Expenditures for food at home	53	53	29	34
6. Decline in value of home-produced food	11	71	—[4]	15
B. Quantity of commodity used, obtained from all sources (increases)				
1. Beef	31	50	22	39
2. Pork	12	21	24	38
3. Decrease in flour bought or home produced	32	28	30	44
4. Flour in baked goods	16	49	43	57
5. Canned vegetables	44	100	12	75
6. Total vegetables	42	112	10	103

[1] Measured by comparing (1) average for the item for each urbanization category computed with (a) the income-size distribution for the other year (on the same dollar basis) and (b) given year's average for each income class with (2) the actual average for the given year.

[2] Using spring 1942 averages for each income class and 1954 income-size distribution.

[3] Using spring 1955 averages for each income class and first quarter 1942 income-size distribution.

[4] Change in pattern of the Engel curve (i.e. income-food relationships) more than offset change expected with higher income.

Source: U. S. Department of Agriculture surveys of household food consumption in spring 1942 and spring 1955.

able money income per person. *Changes in the characteristics of the population* in comparable income classes between 1942 and 1955 could change the curves because these Engel curves represent the relationship between average food use and income for each class. An obvious possibility was the effect of shifts in the regional location of population. A reweighting of the 1955 regional averages for market value of food consumed at home by farm households with 1940 distribution of the farm population calculated from the 1940 Census of Population indicated that this regional shift might have raised the 1942 average for farm households by 2 per cent. But a similar computation for rural nonfarm households pointed to a fractional decline in the average.

Characteristics of the samples for 1942 and 1955, such as size and composition of families, seemed to match pretty well. (There were so few singles in the rural samples for 1942 that they do not affect the comparisons.)

The third exploration led to "pay dirt." The importance of changes be-

tween the two years in the kinds of farmers who were in the lower income range could be appraised using (1) McElveen's information[11] on the decline in classes V and VI farms from 1939 to 1954, (2) census data on cotton farms[12] and data from the 1947 study of food consumption in southern farming areas[13] which indicated a substantially lower level of food consumed in households of cotton farmers in the South than in households of tobacco and general farmers with comparable money incomes. Calculations using these data and the 1955 rates for market value of food for the two lowest income groups led to the conclusion that roughly half of the increase in food consumption from 1942 to 1955 for these groups could be attributed to the decreased proportion of cotton farmers in the two groups.

Another possible factor in the changes in the relationships of the value of food consumed to income could be a *change in urban-rural price relationships.* This would have been hidden by use of the BLS urban Retail Food Price Index and Consumer Price Index to adjust food value data to the spring 1955 price level and the income data to the 1954 price level, respectively. A check on price data for the meat, poultry, and fish group, which holds the key position in the food budget, revealed that average meat prices paid by farm households in spring 1942 were *higher* in relation to spring 1955 average prices than the relationship of BLS urban retail food prices in spring 1942 to spring 1955. The same held true for meat, poultry, and fish bought by lower income farm and rural nonfarm households. So this factor does not appear to have contributed to the rise in the level of Engel curves from 1942 to 1955.

A difference in *pricing of home-produced foods* was another possible reason for the change in level of the rural Engel curves. Information from statisticians in the Institute of Home Economics confirmed the inference from published data that the basis for prices used for calculating the values of home-produced foods was approximately the same for the two surveys.

A frequently heard explanation of increasing dollar outlays for food is the greater use of partially or wholly factory processed foods which in-

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[11] McElveen, Jackson V., *Family Farms in a Changing Economy,* ARS, AIB No. 171, March 1957.

[12] According to the 1954 Census of Agriculture there were 321,000 cotton farms in classes V and VI, about one-fourth of all class V, VI and subsistence farms. The 1940 Census does not provide comparable data but shows 1,590,000 farms reporting cotton, compared with 864,000 in 1954. Apparently most of the decline was in small cotton farms. The number of farms reporting tobacco and the number of noncommercial farms changed little. Therefore, the proportion of low-income cotton farmers in the total number of low-income farmers in 1942 may have been 40 to 50 per cent.

[13] Page 67, *Family Food Consumption in Three Types of Farming Areas of the South, I. An Analysis of 1947 Food Data,* Southern Cooperative Series Bulletin 7, June 1950.

clude the costs of additional marketing services. But canned foods often cost less at retail per pound of farm product than fresh—particularly for vegetables and milk. On the other hand, the shift to more purchased baked goods may have raised average expenditures by U. S. farm households for flour, cereals, and baked goods about 5 cents per person in a week from spring 1942 to 1955, equivalent to about 10 per cent of the total increase. Study of such data for low-income farm households led to the conclusion that the shift to processed foods contributed only slightly to higher food outlays by these households.

The shift to commercially processed foods is only part of a more significant change in rural food habits, namely, *increased reliance on purchased foods.* This general factor does not affect the data on market value of all food consumed at home because foods obtained without direct expense are valued at prices paid by households in that urbanization group (and region in 1955). Rural use of purchased food was much more frequent and extensive in 1955 than in 1942, both on the average and among all income classes. This apparently resulted from increased accessibility to and use of well-stocked food markets. Greater mobility of rural people has come with better roads, off-farm employment, and changed ways of living.

The over-all significance to the commercial food market of increased expenditures for food by rural families will be measured in the next section, but some comments on changes in sources of commodities at this point may bring the changes taking place within the rural food sector between 1942 and 1955 into better focus.

Meats and poultry were the only items for which the average quantity of home-produced supplies used per person by *farm* households increased from spring 1942 to spring 1955, though both the quantities and the proportions purchased actually increased. For eggs and dairy products, home production went down and both average quantities and proportions purchased by farm households rose. Data on consumption in a week of spring showed an increase in use of purchased fruits and vegetables from 1942 to 1955 and a slight decline in home production.

Rural nonfarm households at all income levels increased their purchases of food. Home production of livestock products was greatly reduced. Though more fruits and vegetables were purchased, home-production held up pretty well, according to spring data from the two surveys.

Another reason often given for increased food expenditures is the *shift to higher priced foods.* Part of this shift resulted from increases in average real income, but households with comparable real incomes used and bought more of the higher-priced foods in spring 1955 than in 1942, i.e.—the Engel curves shifted upward.

The increase in market value of meat, poultry and fish consumed per

person in a week from spring 1942 to spring 1955 explained about four-fifths of the rise in the position of the Engel curve for *farm* households in the classes with incomes under $1,000 in 1942 (in current dollars). The increase in value of meat, poultry and fish continued across the whole income range though the farm Engel curves of market value of food at home in spring 1942 and 1955 were close in the upper range of income. In the latter area it was offset by a decline in the consumption of some other food items.

For *rural nonfarm* households in the lower income range, the increase in consumption of meat, poultry and fish explained about two-thirds or more of a rise in the over-all level of food consumption at home (i.e., the Engel curve for market value of food at home per person). Among higher income households living in the open country but not operating farms, the change in meat, poultry and fish was at least equal to the rise in the Engel curve for all food.

It is not sufficient for demand analysis to know where changes in income-food relationships have occurred in the past. One must also know *why* if knowledge necessary for projection of changes into the future is to be accumulated. Detailed statistics on meat and poultry consumption by low-income households in total, by item, and by source provide clues to the reasons for past changes. For the lowest income class of *farm* families (below $500 family income in 1942 and $1,000 in 1954), the significant change was in purchases of meat, which doubled, and probably came from the decreased proportion of southern cotton farmers in the group. The small change in timing of the collection of survey schedules from April and May only in 1942 to April, May, June 1955 may have raised the average consumption rates for poultry, especially young chickens.

Changes from 1942 to 1955 in meat consumption and in meat purchases by households in the next to the lowest income class of farm households ($500 to $1,000 in 1942 dollars, $1,000 to $2,000 in 1954) were comparable to those just described except for a notable 20 per cent increase in the use of home-produced meat—mostly beef. More about this later.

Among low-income *rural nonfarm* households, consumption of home-produced meat was only half as large in 1955 as in 1942, with most of the change in pork. But the significant change in their meat picture was the great increase in purchases of lean pork cuts, beef, luncheon meats and frankfurters—as well as poultry. The key to this shift may lie in the location of employment of the heads of rural nonfarm families—more in towns now, less as hired labor in farming areas. This shift would provide greater opportunity for buying meats as well as increasing the desire for "city" foods.

The most important factor behind generally higher meat consumption by farm households (and by higher income rural nonfarm households) in

spring 1955 compared with early 1940's was the availability and use of freezers and locker plants. Survey data on 1954 production of meat for home consumption show that, in households with less than $6,000 income, home production of meat was about three times as high in households using freezers or lockers as in those without access to such facilities. Above the $6,000 income point, home production was a little over twice as great. Supplementing these data are some from the north central survey of spring 1952[14] which show that at each income level, farm households *without* freezing facilities consumed significantly less meat per person than did households *with* such facilities. The same relationship held true for rural nonfarm households with incomes below $4,000, but the relationship was reversed among rural nonfarm households of higher incomes.

Therefore, the conclusion follows that the changes in farm and rural nonfarm relationships of *market value* of all food consumed at home to income between 1942 and 1955 arose primarily from increases in meat and poultry. Increases in purchases of other foods as well as meat and poultry contributed to the rise in the income-*expenditure* relationships or Engel curves for expenditures for food used at home by farm and rural nonfarm households.

Impact of Major Factors on U. S. Commercial Food Market

Data from the household surveys provide the means for measuring the impacts on the U. S. commercial food market of major economic and social factors bringing about changes in rural food consumption between spring 1942 and spring 1955. The effects of changes in rural food consumption can be separated from those of urban food changes.

First, a word about *food price changes.* The BLS urban Retail Food Price Index rose 83 per cent from April-May 1942 to April-June 1955. Food price changes apparently were no greater for rural households than for urban purchasers.

Next, there were *population shifts.* As pointed out earlier, the reduction in the proportion of cotton farmers among low-income farmers apparently raised the relationship of food consumption to income in the two lowest income groups of farm households and thereby accounted for much of the decrease in the elasticity at the lower end of the Engel curves for market value of food consumed at home and for food expenditures. The effect of such changes in the make-up of the rural population is measured along with other parts of changes in rural food patterns in relation to income in the paragraphs below.

[14] From Table 68 of *Food Consumption and Dietary Levels of Rural Families in the North Central Region, 1952* by Mollie Orshansky *et al.* ARS, AIB No. 157, November 1957, pp. 158-159.

The *regional* shift in farm population affected farm food consumption only slightly, as shown earlier, and was offset by the regional shift in the rural nonfarm population. So this factor had no measurable impact on food sales (as measured by its effect on food expenditures) or on the level of U. S. food consumption.

In contrast, *urbanization* shifts in the housekeeping population from farm to rural nonfarm have significantly affected the *commercial* food market, but have had much less effect on the general level of food consumption—except insofar as such shifts have been tied in with changes in income. Reweighting the 1942 U. S. averages for the three urbanizations with the 1955 distribution of population by urbanization (given earlier in this article), and vice versa, indicates that the urbanization shift had raised average U. S. expenditures per person for food both away from home and at home about 3 per cent each from spring 1942 to 1955. Among major foods, the urbanization shift apparently increased the purchases of dairy products for home consumption about 8 per cent, meats 5 per cent, and fruit and vegetables 3 per cent; but it had relatively little effect on the commercial market for poultry and for grain products.

Higher incomes have brought about most of the increase in the rural demand for commercially produced and marketed foods. The rise in the levels of real income of rural families between first quarter 1942 and the year 1954 apparently raised average U. S. expenditures per person for food at home by 4 per cent and expenditures away from home by 8 per cent.[15] The U. S. market value per person of all food consumed at home also rose about 4 per cent because of higher rural incomes. Among major foods, the income factor increased U. S. purchases of dairy products 5 to 8 per cent per person, meats 3 to 6 per cent, all fruits and vegetables 6 per cent. (The ranges here reflect differences between measurements based on 1942 and on 1955 patterns.)

Increases in the U. S. commercial food market arising from changes in the rural food sector which have *not* been explained by urbanization and income shifts are attributed in the following measures to *changes in rural patterns of food consumption* with respect to income, or stated more precisely, to changes in the Engel curves for each urbanization category. These changes in Engel curves from 1942 to 1955 were the net result of factors discussed above—primarily changes in ways of living and eating,

[15] Derived by (1) reweighting spring 1942 and spring 1955 averages per person for each income class of rural nonfarm and of farm households by the income-size distribution for that urbanization in the other year; (2) combining these computed averages with the actual average for urban households, using the same year's percentage distribution of the population by urbanization; then (3) comparing the U. S. averages so derived with the U. S. averages per person computed from the survey reports.

but shifts in the make-up of the population in each income class within each urbanization category also entered in.

Such changes in Engel curves of rural households affected average U. S. expenditures or dollar outlays per person for food at home and away from home more than they did over-all food consumption which includes home-produced food. The reduction in the elasticity of the farm curve of market value of food at home and some raising of the level of the farm and rural nonfarm curves resulted in a 3 to 4 per cent increase in U. S. average market value of food consumed at home. This was largely in meat and poultry and reflected the reduction in number of cotton farmers, the effect of home freezing, and changes in ways rural people chose to obtain their food. Increased *purchases* of food for home use by rural households at all levels of income raised the U. S. average by 6 per cent and accounted for practically all of the net change in *expenditure patterns* for food at home by the U. S. housekeeping population from spring 1942 to spring 1955. Changes in the urban Engel curve were offsetting, i.e. the curve was higher for lowest income classes and lower for highest income groups of households.

Rural families followed the lead of their city cousins by spending much more per person (in constant dollars) for food and beverages away from home in 1955 at every income level than in 1942. In so doing, they pushed up the U. S. average about 15 per cent.

Changes in rural purchase patterns with respect to income apparently raised average U. S. purchases per person of dairy products (excluding butter) about 15 per cent from 1942 to 1955; meats, 10 per cent; poultry, around 30 per cent; grain products, 5 per cent; had little effect on vegetables and fruits in total; and reduced butter sales slightly.

Included in the above measures of the effects on the U. S. commercial food market of changes in rural incomes and in rural food patterns are the effects of the shift from home production to purchases of food (as well as net increases in food consumption). Recall that average U. S. expenditures for food at home in a week were raised about 4 per cent by the rural income change and 6 per cent by the change in rural food patterns. Of this 10 per cent in total, 7 per cent represented a shift from home production to commercially produced and marketed foods.[16]

To sum up, expenditures for food at home by the U. S. housekeeping population averaged $2.85 per person in a week of spring 1942, compared with $6.27 in spring 1955. Increasing the 1942 U. S. average by 83 per cent (the increase in the BLS Index of Retail Food Prices paid by urban families of moderate income), the average in comparable prices is $5.22

[16] Measured by applying 1942 and 1955 percentages not home-produced to average money value of all food at home for farm and rural nonfarm households and combining the computed figures with the 1955 distribution by urbanization.

for 1942. The total effect on food expense for home use per person of the regional shift (nil), urbanization shift (3 per cent), higher incomes of rural population (4 per cent), and of changes in rural food patterns (6 per cent) is 13 per cent. Applying this percentage to the $5.22 figure, the figure of $5.90 is obtained, accounting for two-thirds of the change in U. S. average dollar outlays for food at home from 1942 to 1955, in constant dollars. The remaining third came from changes within the urban sector.

In other words, changes in average rates of rural food consumption combined with the net shift in the distribution of the population from farm to rural nonfarm categories to raise *retail* food sales about 13 per cent per person in the 13-year period. The precise effect on farm sales of food commodities cannot be measured until the structural indexes are completed and used. However, these rural food changes probably increased the per capita demand for commercially produced farm food commodities about 10 per cent.

Potential for Future Changes in U. S. Food Market to Come from the Rural Sector

Data and procedures described in the foregoing sections can also be used to evaluate the extent to which future changes in rural food use may affect both commercial food sales and the demand for commercially produced farm foods. Starting from Daly's economic framework with his projection of a 40 per cent increase in real income from 1956 to 1975 and income-size distributions derived from the 1955 food survey, income-size distributions for each urbanization category were developed, no major changes in the proportional distribution of income were assumed, but a few minor adjustments were made to keep to the over-all average.[17] For the urbanization breakdown, Louis Ducoff's projection of the farm population for 1975 was used (about 7 per cent of U. S. population),[18] an approximation of 75 per cent for urban (because of the increasing concentration of population), and the remaining 18 per cent for the rural nonfarm category. (Because urban and rural nonfarm food patterns are becoming more alike, the 75-18 break is not particularly important.)

Combination of this rather arbitrary but reasonable projection of the urbanization distribution for 1975 and the spring 1955 averages for each urbanization indicates that average U. S. expenditures per person for food at home might rise 5 per cent from 1955 to 1975 because of the increasing

[17] The 1955 survey's income data were for 1954 incomes; so the projected increase from 1954 to 1975 amounts to 50 per cent.

[18] In "The Farm Population and the Agricultural Labor Force in 1975," *Applications of Demography; The Population Situation in the U. S. in 1975*, edited by Donald J. Bogue, published by Scripps Foundation for Research in Population Problems (Miami University) and Population Research and Training Center (University of Chicago), 1957.

degree of *urbanization*. Expenditures for food and beverages away from home might be increased 10 per cent. If so, total dollar outlays of the U. S. population for food might rise 6 per cent per person.

Higher rural incomes could be expected to push up U. S. average expenditures per person for food at home by 4 per cent, for food and beverages away from home about 11 per cent, and total food outlays per person about 5 per cent.

Whereas changes in rural food purchases in relation to income resulted in a 6 per cent increase in expenditures for food at home between 1942 and 1955, such changes for the much smaller proportion of population living in rural areas by 1975 are not likely to raise average U. S. food expenditures by more than 2 or 3 per cent.

Adding these parts indicates that *future changes in the rural sector alone* combined with the urbanization shift may increase average U. S. expenditures per person for food at home by 10 per cent from 1955 to 1975, for food and beverages away from home, 20 per cent or so, and all dollar outlays for food by 12 per cent.

Relative Significance of the Rural Food Market

The rural food market appears to have accounted for one-fourth of U. S. sales of food for home consumption in 1942 and one-third in 1955. By 1975 the share is likely to drop to one-fifth of dollar sales. Although away-from-home eating by the rural housekeeping population apparently totaled one-eighth of total sales of food and beverages *to the housekeeping population* in 1942, one-fourth in 1955, and may amount to one-fifth in 1975, these figures materially overstate the significance of the rural sector in *total* sales of meals and beverages to the entire U. S. population. Meals, beverages and snacks consumed by the institutional population and by other parts of the nonhousekeeping population (primarily urban) have *not* been added to the totals because no data exist for measuring them.

A rough approximation of the significance of the rural population in the retail value of all food sold (excluding extra services with food and beverages eaten away from home) was estimated by adding two-thirds of the away-from-home dollar data (their retail equivalent) to the expenditures for food at home. The results were only fractionally different from the figures given above for the at-home segment only.

Finally, we must consider the significance of these findings on changes in rural food consumption to analysis of the future demand for farm food commodities for the country as a whole. In an earlier paper it was reported that whereas U. S. per capita use of farm foods increased 6 per cent from 1941 to 1955, 14 per cent more farm food per capita was sold by farmers and moved through commercial channels to ultimate con-

sumers.[19] Increases in *food purchases* by the rural nonfarm and farm population combined with increased demand of the urban sector may result in an 18 to 20 per cent increase from 1955 to 1975 in the retail value of farm foods *sold* as food and as meals and snacks, on the basis of Daly's economic framework for 1975. Allowing for some increase in the marketing margin, the increase in demand at the *farm* level might be 16 to 18 per cent.

Projections of household food survey data indicate that the retail value of all farm foods *consumed* (including home-produced food) would be likely to rise 13 or 14 per cent. After allowance for further increase in marketing margins and for the slight increase in per capita use of farm foods from 1955 to 1956, this measure is entirely consistent with Daly's projection of about a 10 per cent increase in U. S. per capita use of farm foods from 1956 to 1975.[20]

An economic analyst's use of statistical measures is sometimes determined more by the availability of data than by precise fitting of the concepts measured by such data to the needs of the problem being studied. This often seems the case in demand analyses. Most of the over-all food measures have pertained to food consumption from all sources. When an analysis of prospective demands for farm food commodities has the primary objective of determining the effects of changes in demand on cash receipts of farmers, it should be made using the concept of foods sold. But when the demand projections are made to determine the future level of consumption of farm foods, the analyst should properly be concerned with foods from all sources, including home production. Choice between these two concepts has been confused because of our ignorance of the importance to the demand for the output of commercial agriculture of increased purchases by the rural population. A 5 per cent differential between the two sets of per capita projections is not insignificant for a 40 per cent larger population.

Study of changes in rural food consumption not only creates awareness of the over-all significance of such changes, it points up the need for a new item by item analysis of demand, requiring development of supplementary time-series data and use of the new survey material. Moreover, other important findings about changes in food consumption and marketing are likely to turn up in the course of such research.

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[19] "Income-Food Relationships from Time Series and Cross-Section Surveys" in the *Proceedings of the Business and Economics Statistics Section* of the 1957 Annual Meeting of the American Statistical Association, pp. 103-117. The 14 per cent figure, derived from analysis of time-series data on food disappearance and home production now appears to be on the low side, based on more recent analysis of survey data.

[20] Daly's revised estimates (1957) involve use of information from the supply-utilization index which includes home food production by farm and nonfarm households.

THE DEMAND FOR FERTILIZER: AN ECONOMIC INTERPRETATION OF A TECHNICAL CHANGE

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Introduction and Summary

ECONOMETRIC studies of the markets for farm products have a long history and we have accumulated a large amount of quantitative information about them. We know much less, however, about the demand and supply elasticities of various factors of production in agriculture. That this knowledge is important is hard to overemphasize. Almost every policy discussion bogs down in disagreement about the quantitative behavior of the various factor markets. Also, almost all of the large increases in agricultural production have been associated with substantial increases in purchased farm inputs: fertilizer, machinery, seed, and others. An understanding of what has happened to these inputs and why is indispensable both to an understanding of the behavior of the supply of agricultural products and to an explanation of the great technological changes that have occurred in agriculture.

This paper investigates only the use of fertilizer. Since 1940, fertilizer use in the U. S., measured in units of principal plant nutrients, has approximately trebled, and this increase has been hailed as one of the great technological changes of our times.

This paper explains the changes in fertilizer use with the help of a very simple econometric model. Basically, it consists of saying that fertilizer use is a function of the "real" price of fertilizer, the price paid for fertilizer relative to the prices received for farm products, and the realization that adjustment to a disequilibrium is not instantaneous. By assuming that fertilizer use is a function of the real price of fertilizer but allowing the adjustment to a change in the price to be spread over more than just one year, i.e., distinguishing between a "short" and a "long run" demand elasticity for fertilizer, the changes in aggregate U. S. fertilizer use during the period 1911-1956 are explained. And the explanation fits the 1934-1956 data as well as the 1911-1933 data.

This allows one to put "technological changes" in this area into their proper perspective. The tremendous increase in the use of fertilizer can be interpreted largely as a movement along a given production function in response to changing relative prices. The "technological change," using

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the term properly to mean the discovery of really new production techniques, occurred largely outside of agriculture in the fertilizer industry. The important technological changes were not so much in the discovery of new facts about the use of fertilizer or in the spread of this knowledge, but in the discovery of new processes of producing fertilizer which resulted in a substantive secular fall in the real price of fertilizer. This is not to imply that no important new knowledge about fertilizer was discovered, or to deny the importance of the general spread and increase of our knowledge about the uses of fertilizer in agriculture. But it is suggested that this increase in knowledge about fertilizer within agriculture can be interpreted as a response to the large fall in the real price of fertilizer, as being an induced innovation which should not be assigned an autonomous or exogenous role.

Previous Work

Most of the research on fertilizer use has been concentrated on investigating the physical relationships betwen fertilizer input and the yield of crops and on prescribing, on the basis of these physical studies, what farmers ought to be doing.[1] Very little has been done, however, to explain what farmers are actually doing.

In 1927 and 1932 E. E. Vail published several indices of wholesale and retail prices of various fertilizer materials, explored the relationships between wholesale and retail prices, and related the differences in the prices of various mixed fertilizers to the differences in their nutrient content. He also related U. S. fertilizer consumption to various factors, finding that the lagged value of cotton per acre and the lagged value of tobacco per acre contributed most to an explanation of the variations in fertilizer consumption. He did not find any statistically significant relationship between the price paid for fertilizer and fertilizer consumption.[2] In the middle 1940's, A. L. Mehring, B. T. Shaw, and others at the U. S. Department of Agriculture published several quantitative studies on

[1] For an example, see E. L. Baum, *et al.*, eds., *Economic and Technical Analysis of Fertilizer Innovations and Resource Use*, Iowa State College Press, Ames, 1957, and the literature cited there.

[2] E. E. Vail, "Prices of Fertilizer Materials and Factors Affecting the Fertilizer Tonnage," Cornell University Ph.D. thesis, Ithaca, 1927; and "Retail Prices of Fertilizer Materials and Mixed Fertilizers," N.Y. (Cornell) AES, Bul. 545, Ithaca, November, 1932.

[3] A. L. Mehring and B. T. Shaw, "Relationships Between Farm Income and Farmers' Expenditures for Fertilizer and a Forecast of the Commercial Demand for Fertilizer in 1944 and 1945, by States," *American Fertilizer*, C. 1944; A. L. Mehring, "Fertilizer Nitrogen Consumption," *Industrial and Engineering Chemistry*, XXXVII, March 1945; B. T. Shaw, F. W. Parker ,and M. J. B. Ezekiel, "Price Factors in Plant Food Consumption," *ibid.*, and other publications. See the bibliography in USDA Statistical Bulletin 191.

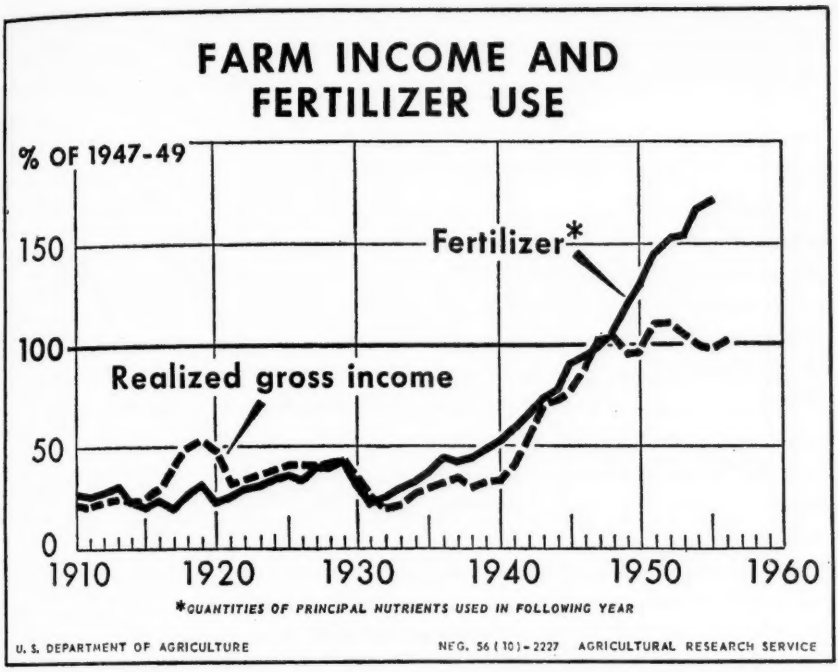

FIG. 1. FARM INCOME AND FERTILIZER USE

factors affecting the use of fertilizer.[3] Most of these studies were concerned with the relationship between expenditures on fertilizers and lagged farm income. It was claimed that farmers spend a constant proportion of their income on fertilizers.[4] These studies also included a cross-sectional analysis by states relating nitrogen consumption per acre to crop value per acre, the nitrogen content of soil, the proportion of total cash income from livestock, and a time series analysis of changes in the mix of plant nutrients in response to changes in their relative prices. None of these studies, except Vail's, has considered the price of fertilizer relative to other prices as one of the major variables.

Recently, Iowa farmers were surveyed on factors affecting the acceptance and use of fertilizer.[5] Of all the variables, only the amount of fertil-

[4] The constancy of this relationship is not too impressive. U.S. farm expenditures on fertilizers as a per cent of previous year's gross income (excluding livestock) varied from 3.1 per cent in 1931 to 7.8 per cent in 1952; and as a per cent of total production expenses (including livestock), they varied from 2.7 in 1927 to 5.0 in 1953. See USDA, Commodity Stabilization Service, *The Fertilizer Situation for 1954-1955*, Washington, September 1954, Table 5.

[5] M. A. Anderson, *et al.*, *An Appraisal of Factors Affecting the Acceptance and Use of Fertilizer in Iowa, 1953*, Iowa Agricultural Experiment Station, Special Report No. 16, Ames, 1956.

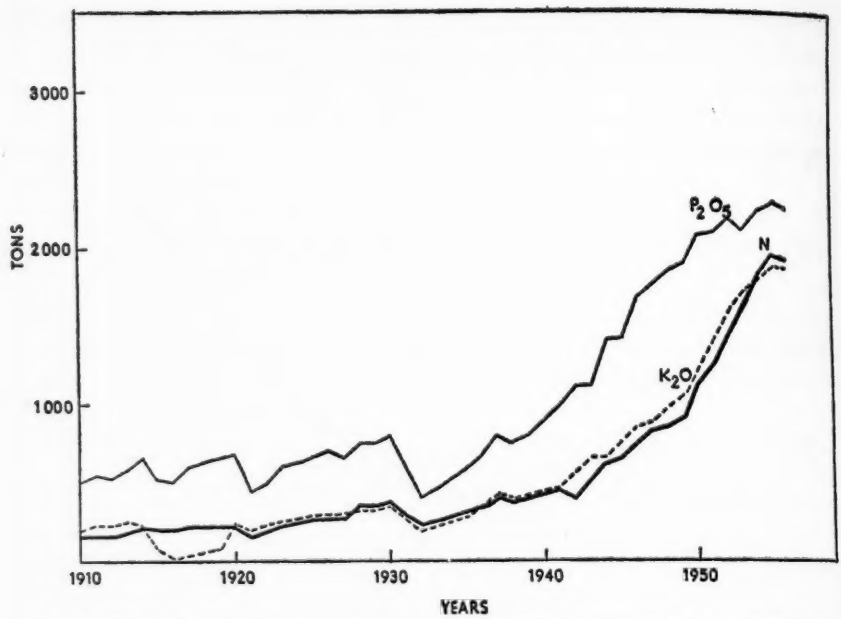

FIG. 2. U. S. USE OF PLANT NUTRIENTS, 1910-1956. Source: U.S.D.A. Statistical Bulletin No. 191 and Subsequent ARS releases.

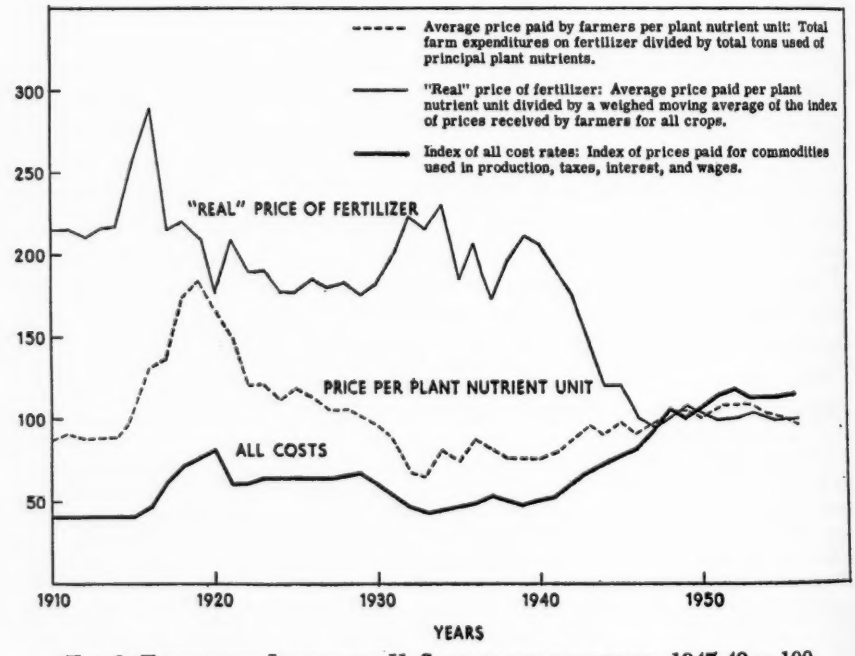
Average price paid by farmers per plant nutrient unit: Total farm expenditures on fertilizer divided by total tons used of principal plant nutrients.
"Real" price of fertilizer: Average price paid per plant nutrient unit divided by a weighed moving average of the index of prices received by farmers for all crops.
Index of all cost rates: Index of prices paid for commodities used in production, taxes, interest, and wages.
300
250
200
150
100
50
"REAL" PRICE OF FERTILIZER
PRICE PER PLANT NUTRIENT UNIT
ALL COSTS
1910
1920
1930
1940
1950
YEARS

FIG. 3. FERTILIZER: INDEXES OF U. S. PRICE DEVELOPMENTS, 1947-49 = 100.

izer used in the previous year and the size of farm seemed to be significantly related to the amount of all fertilizers used on different farms. Most of the findings of this survey, however, are not directly applicable to this paper.

Historical Background

The major historical facts about fertilizer use in the U. S. are presented in Figures 1, 2, and 3. Figure 1 illustrates both the similarity of the time series of fertilizer use to that of realized farm gross income and the divergence of these two series in the post World War II period. It also shows how large the increases in fertilizer use have been. Fertilizer use trebled between 1940 and 1952. Figure 2 presents separately the trends in the use of the three principal plant nutrients, nitrogen, phosphoric acid, and potash. The over-all movements in these three nutrients have been very similar, i.e., the absolute increases have been about the same; however, percentagewise, the use of nitrogen and potash increased much more than the use of phosphoric acid. Figure 3 illustrates some of the price developments. The "real" price of fertilizer, the price of a plant nutrient unit relative to the price received for all crops, fell by 50 per cent betwen 1940 and 1950, with most of the fall occurring between 1940 and 1945.[6] This fall was the result of a substantial rise in the prices received for crops index and a relatively small rise in the price paid for fertilizer. That is, given the general inflationary trends since 1940, the price of fertilizer increased much less than did the prices received for crops and also much less than most of the prices paid for other factors of production.

Besides the developments depicted in these figures, many other things happened during this period which are not discussed in this paper. The most important of these are the rise in the average plant nutrient content of fertilizers from about .18 in the 1930's to over .25 in the 1950's; the increase in the use of nitrogen and potash relative to phosphoric acid (depicted in Figure 2), the great rise in fertilizer use in the Midwest relative to the U. S. as a whole (from an index of 100 in 1947-49, plant nutrient consumption in the West North Central States increased to an index of 328 in 1955 as compared to an increase to 168 for the U. S. as a whole); and the rapid rise of "liquid fertilizers," in particular liquid nitrogen, in

[6] The "real" price of fertilizer in Figure 3 is defined as the average price paid per plant nutrient unit (total farm expenditures on fertilizer divided by the quantity of plant nutrients used) divided by a weighted moving average of the index of prices received by farmers for all crops ($P^*_{ct} = .5\ P_{ct} + .25\ P_{ct-1} + .125\ P_{ct-2} + .0625\ P_{ct-3}$). This averaging was done to smooth out some of the short run variability in the prices received index.

the post World War II period. The latter, however, still constitutes only a small proportion of total fertilizer consumption in the U. S.[7]

The Hypothesis and the Method

The hypothesis tested is that the substantial increase in the use of fertilizer has come about essentially as a response to a fall in the relative price of fertilizer, a fall both relative to the prices received for crops and to the prices paid for other inputs. This is accomplished by defining and estimating an aggregate U. S. demand function for fertilizer and investigating whether it can explain most of the variation in fertilizer use. In particular, does the explanation that fits the 1911-1933 period also explain the 1934-1956 period, the period of the great change?

The Model

The model used consists of two parts: a long run demand function and an adjustment equation. The demand function used considers fertilizer use to be a function of all the relevant product and input prices, permitting both output and other inputs to vary. This definition was chosen because output and the level of other inputs are determined more or less simultaneously with the level of fertilizer, whereas prices, either expected or paid by the farmer, can be considered exogenous and not affected, in the short run, by his decisions. On the aggregate level, of course, this is less true. The sum total of individual decisions will affect market prices, but it still seems more useful to consider fertilizer consumption as responding to changes in all prices than to attempt to hold the level of some of the other inputs or of output constant.

The functional form chosen for the estimation of the demand function is an equation linear in the logarithms of the variables. While a theoretical rationale for this form could be developed, the actual choice was suggested by the inspection of the original data with the aid of scatter diagrams.[8]

The definition and specification of the demand function does not really raise new problems. The introduction of an adjustment equation, however, bears closer examination. The idea—that an adjustment to a change in prices or to a change in any of the other independent variables takes time—is not new. It goes back at least to Marshall, underlying his dis-

[7] In 1956 anhydrous ammonia and nitrogen solutions constituted about 2.4 per cent of the total tonnage of all fertilizers consumed and about 5.0 per cent of total plant nutrient consumption.

[8] A Cobb-Douglas production function between farm output and fertilizer, land, and other inputs, profit maximization by individual farmers, and constant returns to scale, imply a demand function for fertilizer linear in the logarithms of the variables.

tinction between the "short" and the "long" run.[9] It has also been very well expressed by Scitovsky:

> The average consumer has fixed consumption habits, which he has acquired on the basis of past price constellations; and it takes time for a changed price to break an old habit and form a new one. When relative prices change or new opportunities arise, the consumer usually continues in his accustomed grooves for a while, because he needs time to learn about a change, to appraise its significance, and more time still to adapt his behavior to it and face the inconveniences or hazards that changing one's behavior often involves. In other words, people's propensity to form habits and their slowness in adapting themselves to changed circumstances render their economic behavior a function not only of current but also of past prices. The equating of marginal values to prices must be conceived of more as a goal constantly aimed at and approximated than as something actually accomplished at every moment of time.[10]

All this is true, *a fortiori*, of a producer. It is reasonable to assume that, given a change in the independent variables, different reactions will occur depending on whether these changes are expected to persist or not. If they persist, the reaction will be cumulative. Also, while a substantial reduction in the real price of fertilizer may be followed by an immediate increase in use by farmers already using fertilizer, this change may also make fertilizer use profitable to a large number of farmers who had never used it before and are unfamiliar with its technology. There will be a learning process involved for new fertilizer users and for others with new fertilizer uses. This process will take time and will persist only if the price change persists for a long enough period.

While these considerations are not new, until recently no useful methods for dealing with such problems were available, and very little was done about them. The method used in this study owes its origin to the work of Cagan,[11] Friedman,[12] Koyck,[13] and most importantly, to Marc Nerlove's interpretation and extension of their work.[14] Basically it consists of distinguishing between actual and "desired" use. The demand function

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[9] Marshall, Alfred, *Principles of Economics*, 8th ed., 109-110.

[10] Scitovsky, Tibor, *Welfare and Competition*, 1951, 48-49.

[11] Cagan, Phillip, "The Monetary Dynamics of Hyperinflation," in Friedman, M., ed., *Studies in the Quantity Theory of Money*, University of Chicago Press, 1956, 25-120.

[12] Friedman, Milton, *A Theory of the Consumption Function*, Princeton University Press, 1957.

[13] Koyck, L. M., *Distributed Lags and Investment Analysis*, North Holland Publishing Co., Amsterdam, 1954.

[14] Nerlove, Marc, "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," *Journal of Farm Economics*, Vol. 38 (2), May 1956; "The Implications of Friedman's Permanent Income Hypothesis for Demand Analysis—a Review," *Agricultural Economics Research*, X (1), January 1958; and *Distributed Lags* and *Demand Analysis for Agricultural and Other Commodities*, U. S. Department of Agriculture Handbook, No. 141, June, 1958.

determines the "desired" use, the long run equilibrium level of use. Between one period and the next, however, actual use changes only by some fraction of the difference between the current use and the "desired" use. Between one period and the next, you will travel only a fraction of the distance which separates you from where you are and where you would like to be if you could adjust instantaneously, where you would want to be if adjustments were painless and cost less, and if you really believed that the current data (prices) would persist where they are and not change again tomorrow and make a new and different adjustment necessary. The adjustment equation assumes that the farmer moves in the direction of eliminating the disequilibrium but does not necessarily eliminate it all at once. Actually, equilibrium would be attained only if all the independent variables were to remain constant, which they never do. Operationally, we assume that the change in fertilizer use is a function of the difference between "desired" and current use. In particular, we assume that the adjustment function is linear in the logarithms of desired and actual consumption; hence, the implicit adjustment path is nonlinear, slowing down as the difference between the two becomes small.[15]

Algebraically, the model is expressed as follows. Let lower case letters stand for the logarithms of the variables.

Then:

$$y^*_t = a_o + a_1x_{1t} + a_2x_{2t} + u_t, \tag{1}$$

where y^*_t is the desired fertilizer consumption, x_1 is the price of fertilizer relative to the prices received for crops, x_2 is the price of fertilizer relative to the prices paid for other factors of production and u_t is a disturbance.

The adjustment equation is:

$$y_t - y_{t-1} = b(y^*_t - y_{t-1}). \tag{2}$$

That is, converting back into the original units, $Y_t/Y_{t-1} = (Y^*_t/Y_{t-1})^b$, the percentage change in actual consumption is a power function of the percentage difference between "desired" and actual consumption.

Substituting (1) into (2) and solving for y_t we get our estimating equation:

$$y_t = ba_o + ba_1x_1 + ba_2x_2 + (1 - b)y_{t-1} + bu_t. \tag{3}$$

This is the basic equation estimated in the following sections. It was fitted to U. S. data covering a rather long period as time series go, 1911-

[15] The assumption of an "expected price" model, where the expected price is a function of all past prices, leads to similar expirical implications.

1956. Those 46 years included two world wars, the great depression, and several smaller agricultural price cycles.

The Data and the Variables

"Fertilizer" is an aggregate. It consists mainly of different nitrogen, phosphoric acid, and potash compounds and could be measured in many different ways. Clearly, however, the total weight of all fertilizers used is not an adequate measure from the point of view of economic analysis. I shall use the USDA measure of "principal plant nutrients" which measures fertilizer use in terms of the total quantities of the three principal plant nutrients (N, P_2O_5, and K_2O) contained therein. This measure assumes that these are the elements which directly affect production and therefore they are the thing that farmers are buying. It assumes that farmers are mostly interested in the quantity of actual "plant food" contained in the fertilizer and do not care about its total weight.[16] Moreover, it assumes that farmers are indifferent between various kinds of fertilizers as long as they contain the same tonnage of "plant foods," assuming a perfect substitution between N, P_2O_5, and K_2O, as their respective tonnages are simply added up to get at the total plant nutrient use.

An alternative measure could be constructed using the prices of different fertilizers as weights. No price weighted index has been published and its construction would be a major undertaking; it can be approximated, however, by aggregating the published series on nitrogen, phosphoric acid, and potash consumption. Implicit price weights for N, P_2O_5, and K_2O can be derived from an analysis of the relationship between the prices of different mixed fertilizers and their nutrient content. Such an analysis was made by the author on 1955 prices, and a similar analysis was published by Vail (*op. cit.*) on 1924-28 prices of mixed fertilizers in Pennsylvania. Using the 1955 and 1924-28 weights, two alternative price weighted measures of total fertilizer consumption were constructed.[17]

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[16] The use of principal plant nutrients as the dependent variable is analogous to the use of gallons of pure alcohol as a measure of total liquor consumption in an analysis of the demand for liquor. That is, the assumption would be that liquor is drunk to get drunk, for which purpose only the alcohol content and not the form in which it is consumed matters. While this may be a poor assumption to use in the analysis of liquor demand, it could be a reasonably good assumption for the analysis of the demand for fertilizer, as fertilizer is a factor of production and "taste" differences may play a minor role.

[17] Using the average U. S. prices for different mixed fertilizers reported in *Agricultural Prices*, September, 1955, I computed the following regression of the average price paid for 24 different mixed fertilizers on their percentage content of N, P_2O_5, and K_2O:

$$\text{Pr./ton} = \underset{(3.46)}{2.22} + \underset{(.37)}{3.40N} + \underset{(.15)}{1.95P} + \underset{(.23)}{.95K} \qquad R^2 = .945$$

Even though the weights differed widely, neither of the series differed enough from the published principal plant nutrient consumption series to warrant recomputation of previous calculations. The use of 1955 price weights resulted in a series that was practically indistinguishable from the official series. The use of 1924-28 weights made some difference in the level of the series but affected their movements very little.

Because the various aggregate nutrient series differed so little, the USDA estimate of annual (calendar year) U. S. use of principal plant nutrients divided by the index of total cropland used for crops was used as the dependent variable Y.[18] Total cropland, as conventionally measured, changed very little since 1910; hence, the use of this deflator has little effect on the results.[19]

The price of a "plant nutrient unit" is derived by dividing the estimated total farm expenditures on fertilizer by the total quantity of plant nutrients used.[20] This results in a Paasche index of prices paid per unit of principal plant nutrients. To arrive at a "real" price paid for fertilizer X_1, the price paid per plant nutrient unit is divided by the USDA index of prices received by farmers for all crops in the same year.

Several unsuccessful attempts were made to add various other input prices to the analysis, but there is no need to describe them in detail here.[21] Suffice it to say that neither the prices paid for other inputs, including wages, nor the price of land (neither the index of the value of farm real estate per acre nor an index of rent paid per acre) improved the results presented below.

A word should be said about the timing of these variables. All of them

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This regression provides implicit weights approximately proportional to 4-2-1 per pound of N, P_2O_5, and K_2O. For 1924-28 Vail estimated them to be on the order of 7-1-1. The USDA measure used in the text implicitly assumes 1-1-1 weights.

It may be of some interest to note that the constant term in the above regression is not significantly different from zero. Hence we cannot reject the hypothesis that farmers are indifferent between different concentrations of nutrients at the same price per nutrient unit as long as the different sources are qualitatively comparable (i.e., the reference here is to mixed fertilizers of different concentrations rather than to a comparison of mixed fertilizer and separate materials).

[18] Source: USDA, ARS, *Changes in Farm Production and Efficiency*, June 1956, and subsequent ARS releases.

[19] Total cropland changed from an index of 87 in 1910 to 97 in 1920, reached a high of 102 in 1949, and declined to 98 in 1956. See also the results of a regression using undeflated plant nutrient consumption below.

[20] The unpublished expenditure data were made available by the Farm Income Branch of the AMS. The published data in *The Farm Income Situation* also contain expenditures on lime.

[21] Some of these preliminary investigations are reported in greater detail in the author's "Estimates of the U. S. Demand for Fertilizer: A Preliminary Report," unpublished, dittoed, Office of Agricultural Economics Research Paper No. 5711, University of Chicago, October 18, 1957.

are computed on the basis of the calendar year. However, about 75 per cent of all fertilizer is sold in the first half of the year, whereas the prices received for crops index is much more affected by developments in the second half of the year. While this may introduce an error into our analysis, I believe that this error is smaller than is the error that would be made by lagging the prices received index by a whole year. The assumption that farmers are able to predict fall prices in the spring, in the author's opinion, results in less error than the assumption that they base their expectations throughout the year on last year's prices, without taking into account the current price developments. Actually, when prices received as of March 15, rather than calendar year, are used, the results are about the same.

Identification

The problem of the simultaneous determination of various variables exists but does not seem to be too important in this case. Both the prices received and the prices paid for other inputs can be assumed as predetermined. The price of fertilizer is affected by farmers' purchases, but perhaps not very much so, in the short run. Fertilizers are produced and sold by several major firms, with a price tag which is set by these firms and which is not varied too much within the crop season. That is, we are operating here in an area of "administered prices" in the sense that prices are set in advance and any disequilibrium expresses itself in sellers' inventories. Of course, as inventories fluctuate, prices and production are eventually adjusted to bring them back to "desired" levels. But in the short run, the price may be assumed to be predetermined. This assumption gains support from the probable high elasticity of the long run supply of fertilizer and from the wide use of the various basic raw materials in other industrial uses outside agriculture. While the prices of various fertilizers may be predetermined in the short run, the average price paid will be affected by changes in the purchased mix. The average mix seems, however, to change very gradually and can also be considered as predetermined in the short run. Therefore, least squares fitting procedures are used throughout this study.[22]

Results

The results of some of the computations performed are presented below, in Table 1. They are very encouraging. The fit is good and all the coefficients seem reasonable. The coefficient of adjustment is around .25,

[22] The introduction of a lagged dependent variable into the regression in presence of serial correlation in the disturbance could result in biased coefficients. The analysis, however, comes through the test for serial correlation with flying colors.

TABLE 1. REGRESSION RESULTS: U.S. DEMAND FOR FERTILIZER, 1911–1956

	R^2	b	a_1
(1) $\log Y_t = .135 - .529 \log X_{1t} + .764 \log Y_{t-1}$ (.073) (.041)	.980	.24	−2.24
(2) $\log Y_t = .120 - .450 \log X'_{1t} + .790 \log Y_{t-1}$ (.082) (.049)	.974	.21	−2.14
(3) $\log Y'_t = .134 - .536 \log X_{1t} + .766 \log Y'_{t-1}$ (.070) (.134)	.983	.23	−2.29
(4) $\log Y_t = .162 - .570 \log X''_{1t} + .745 \log Y_{t-1}$ (.138) (.071)	.969	.26	−2.24

Note: The figures in parentheses are the calculated standard errors.
Y_t—Total plant nutrient use divided by the index of cropland used for crops.
Y'_t—Total plant nutrient use *not* divided by the index of cropland.
X_{1t}—Price paid per plant nutrient unit divided by the index of prices received by farmers for all crops. Both for the calendar year.
X'_{1t}—Same as X_{1t}, except the prices received index is as of March 15 rather than for the calendar year.
X''_{1t}—Same as X_{1t}, except that a moving weighted average of the prices received index is used in the denominator with weights declining exponentially ($P^*_{ct} = .5P_{ct} + .25P_{ct-1} + .125P_{ct-2} + .0625P_{ct-3}$).
b—The estimated adjustment coefficient.
a_1—The estimated long run price elasticity of the demand for fertilizer.

indicating that approximately 25 per cent of the indicated adjustment is completed within one year and 78 per cent in five years.[23] These regressions imply a substantially higher price elasticity in the long run than in the short run. The elasticity of the demand for fertilizer with respect to its "real" price is estimated to be approximately −.5 in the short run and −2.0 in the long run. Obviously, these are not the only variables affecting the demand for fertilizer, and the omission of other relevant variables would tend to bias the estimates of these coefficients. For these and other reasons, the author believes that his estimate of the long run elasticity is somewhat too high and his estimate of the adjustment coefficient is somewhat too low, but he has not been able to improve upon these estimates by including several other reasonable variables like the price of land and the prices paid for other inputs.

It could be argued that these good results are spurious, due largely to

[23] The adjustment function used does not result in a constant fraction of the disequilibrium being eliminated within one year. This fraction will depend on the magnitude of the disequilibrium. However, within the relevant range it is approximately constant. Given an adjustment coefficient of .25, if the disequilibrium is 10 per cent of the current level, 25 per cent of it will be eliminated wtihin one year. If the disequilibrium is 50 per cent of the current level, the first year's adjustment will eliminate 22 per cent of it, and it will eliminate 19 per cent in the first year if the disequilibrium is as high as a 100 per cent. That is, the percentage of the adjustment completed each year falls somewhat as the magnitude of the disequilibrium increases.

the introduction of the lagged dependent variable into the equation. Of course, the R^2's should be taken with a grain of salt. The relevant measure here is the partial correlation of y_t with x_1 holding y_{t-1} constant. But that is also very high. For equation (3), for example, $r_{y_t x_1 \cdot y_{t-1}} = -.909$. Actually, the lagged value of the dependent variable plays a role akin to that played by "trend" in other analyses. This model provides an economic interpretation why there *should* be serial correlation in the variables. It recognizes the fact that changes in the dependent variable are not independent from what has happened before. This is the virtue of this approach. When the residuals from these regressions are examined, there is no evidence left of either trend, nonlinearity, or serial correlation in the residuals.[24]

TABLE 2. THE U.S. DEMAND FOR FERTILIZER IN SUB-PERIODS

Regression	Coefficients of		R^2	b	a_1
	x_1	y_{t-1}			
(1) 1911–1956	−.529 (.073)	+.764 (.041)	.980	.24	−2.24
(1a) 1911–1933	−.777 (.111)	+.689 (.097)	.816	.31	−2.50

A Test of the Hypothesis

To investigate whether the recent period is radically different from the past, the whole period was divided into two, 1911-1933 and 1934-1956, and a separate regression was computed for the 1911-1933 period. The results of these calculations are presented in Table 2.

The two regressions are surprisingly similar, with none of the coefficients being significantly different from each other. The most important difference between the two is in the higher coefficient of adjustment for the first half of the period. It is not very difficult to interpret this result. While in the first period the real price of fertilizer fluctuated up and down around a stable mean, in the second period we witness a sustained and drastic fall in the real price of fertilizer. The fall in price made fertilizer profitable in many new uses and for many new users. It is not surprising, then, that adjustment to such a change take longer. There is a real learning process involved here.

A more direct way of testing the hypothesis of no structural change is

[24] The value of d, the Watson-Durbin statistic in regression (1), is 1.67. Hence, one cannot reject the hypothesis of no serial correlation in the disturbances.

to answer the question: How well does the first period regression predict in the second period? Using the first period coefficients, the predicted values of Y for 1934-1956 were computed and compared with the actual values. The implied R^2 was .950. This compares with an R^2 of .816 of the same regression during the 1911-1933 period. That is, not only do the 1934-1956 values fall well within the prediction interval of the 1911-1933 regression, but they actually fit it better. Hence, the hypothesis that the 1934-1956 observations come from the same population as the 1911-1933 observations cannot be rejected. That this is so is illustrated again by the fact that when one adds in the 1934-1956 observations and recomputes the regression to cover the whole period, the resulting coefficients do not differ by much from the 1911-1933 regression coefficients. (Compare [1] to [1a] in Table 2.)

In summary, the second period could have been predicted quite successfully from the knowledge of the first period regression, and the prediction would have been better than expected on the basis of the performance of this model during the period from which the coefficients were originally derived!

Other Work

Work is also in progress on an analysis of fertilizer used on cotton, and on a cross-sectional analysis of fertilizer use in the U. S. in 1954. The results of these studies will be reported separately. It is only noted here that they strongly support the conclusions reached in this paper.

The time series analysis of fertilizer used on cotton in the U. S., and a separate analysis of Mississippi data, result in estimates that are very close to those presented in this paper.[25] The cross-sectional data allow one to isolate the impact of different input prices, above and beyond the contribution of the price of fertilizer relative to the price of the product. In particular, the importance of land prices (a substitute input for fertilizer) and wages (a complimentary input) are emphasized.

Conclusions and a Disclaimer

These results do support the general hypothesis. Assuming adjustments that are not instantaneous, it is possible to explain almost all of the variation in fertilizer consumption on the basis of changing relative prices, without either invoking or even mentioning "technological change." Moreover, relationships derived from 1911-1933 data fit the 1934-1956 data quite well, indicating that there may not have been any substantial

[25] They also support Marc Nerlove's estimate (*op. cit.*) of .2 as the short run supply elasticity of cotton acres.

change in the pattern of farmers' behavior with respect to fertilizer.[26]

Obviously, the world is not as simple as this paper makes it out to be. But the virtue of this model is its extreme simplicity. With very little a lot is explained. Of course, if one is interested in more detailed questions, one will need a more detailed model. In particular, the author wants to be explicit on the point that he does not claim that all the people "knew" all the time all there was to know about fertilizers and that as prices changed they recalculated their equilibria positions and changed their use of fertilizer accordingly. Undoubtedly, many Midwestern farmers had never used fertilizers and had little knowledge about them before World War II. Since the war there has been much more research on fertilizer and more dissemination of information about it by colleges, fertilizer companies, and others. These estimates, however, suggest that these developments may have been more a result of the substantial fall in the real price of fertilizer than an independent causative factor in the development.

People do not have information about everything, nor is it important that they should have it. They only need to know the "important" things. In the Midwest, few people know today how to produce bananas, and rightly so. They have more productive alternatives. If, however, relative prices changed so much that banana growing became profitable in the Midwest, the knowledge of banana growing would almost certainly be "produced" albeit with a lag, by colleges and by various profit-seeking groups, and that knowledge would be disseminated fairly rapidly. If an activity becomes profitable, there will be money to be made in supplying "knowledge" about it, and "knowledge" will be produced.[27]

Let this be clear. The author's argument is not that there was no learning process involved in effecting these large increases in fertilizer consumption, only that the process should not be treated as exogenous. This learning process can be viewed largely as the result of changing relative prices and should be treated within the framework of economics and not left outside of it. Any substantial change in relative prices will always involve some "learning" on the part of entrepreneurs. While things are stable there is no point in knowing anything more than the physical and

[26] Only the price paid per plant nutrient unit relative to the index of prices received for all crops was used in the final analysis. This is not to imply that this is the only important price relationship. The model also assigns an important role to the prices of other inputs. It was not possible, however, because of the multicollinearity of the various price series, to assess their contribution separately from time series data. This does not mean that their influence on fertilizer use has been and will be small, only that the author has not succeeded in measuring it. The moral of this paper is not that one price is more important than others. It is rather that we should not omit relative prices from our explanations of technical change.

[27] The history of soybeans in the U.S. is probably a case in point.

economic facts in the neighborhood of the current equilibria. Only when there are substantial changes in the relevant variables is there an incentive to get busy and learn the "new" things.

It is impossible, however, to escape mentioning "technological change" when attempting to explain the secular decline in the real price of fertilizer. Technological advances in production techniques, a reduction in the transportation and handling costs per unit of nutrients with increasing concentrations, and large government investments in nitrogen plant capacity have all played a role in this. But that is a separate story.

THE PRICING STRUCTURE FOR WHEAT AT THE COUNTRY ELEVATOR LEVEL*

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THE wheat market is generally considered one of the best empirical examples of the pricing process under conditions approaching perfect competition. Such reference is ordinarily made but not limited to the futures market. A high degree of pricing efficiency is assumed to prevail at still other stages in the wheat marketing channel.

This paper analyzes the pricing process for soft red winter wheat at the country elevator level in selected areas of Indiana. The results show substantial departures from perfect competition and the kinds of pricing imperfections that are most serious. The findings have implications for any market in which perfect or nearly perfect competition is assumed.

Definition of Concepts

Pure competition is here defined as absence of any monopolistic element, or absence of control over supply and, therefore, over price. A purely competitive market is one in which there is (1) a large number of buyers and sellers so that the influence of any one or of several in combination is negligible, and (2) a homogeneous or standardized product.

Perfect competition requires, *in addition* to the requirements for *pure* competition, such "perfection" as the particular theorist finds useful and convenient to his problem.[1] Absence of friction in some sense is usually implied. This means perfect knowledge about current market conditions, the future, and the product, and further, perfect mobility of factors so "that adjustments to changing conditions which actually involve time are accomplished instantaneously in theory."[2]

This concept is similar to Shepherd's definition of the perfect market in time, place and form, which carried to the abstract limit assumes "(1) a particular commodity, (2) a point in space, and (3) an instant of time."[3] Obviously, there is only one price in such a market.

Perfection may exist, however, even if the commodity is not strictly homogeneous, or if there are space or time periods involved. This is true

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[1] Edward H. Chamberlin, *The Theory of Monopolistic Competition* (Cambridge: Harvard University Press, 1948), pp. 6-7.

[2] *Ibid.*, p. 6.

[3] Geoffrey S. Shepherd, *Marketing Farm Products* (Ames: The Iowa State College Press, 1955), p. 18.

provided that price differentials accurately reflect (1) differences among commodities and among grades of a given commodity, (2) transportation costs and (3) storage costs and correct discounting of the future.

Because these rigid requirements of perfect competition do not hold in reality, the relative efficiency of the process of "price discovery" becomes highly important. This process, state Thomsen and Foote, has two distinct phases.

> "(1) evaluating the conditions of demand and supply and determining the general level of prices for the commodity which will result from these conditions and around which prices for particular lots of the commodity in different locations, of different qualities, and in different transactions will fluctuate; (2) determining the value of a specific lot of the commodity being exchanged relative to the general market level."[4]

This paper deals with the two phases of price discovery for wheat at the country elevator level. For the first phase the analysis is based on elevator quoted paying prices for Number 2 wheat. For the second phase the analysis is based on differences between elevator grading and price discounting (from the quoted Number 2 price) of specific samples of wheat, and laboratory grading and price discounting of the same samples.[5]

The Study of Quoted Prices for Number 2 Wheat

Data on daily paying and selling prices, amounts bought and sold, destinations of sales, and other general information were collected from country elevators during the 1955 wheat harvest season. The sample included all elevators in two areas of Indiana. In the northern area, there were 31 elevators located in three counties at the extreme north central part of the state. In the southern area, there were 26 elevators located in four counties in the southwestern corner of the state. The centers of the two areas are approximately 250 miles apart. Wheat sales make up around 5 to 10 per cent of the value of farm products sold for counties in the northern area and 10 to 15 per cent for counties in the southern area.

An estimated 90-95 per cent of Indiana wheat moves directly from the field to the country elevator. Moreover, as the wheat within each area all ripens within a relatively short period of time, a large volume must be handled by country elevators within a few days (Figure 1). The time is

[4] F. L. Thomsen and R. J. Foote, *Agricultural Prices* (New York: McGraw-Hill Book Company, 1952), p. 120.

[5] The findings presented are from two Purdue University unpublished M.S. theses: John W. Banta, "Wheat Price Variations among Local Elevators in Two Areas of Indiana," June, 1957, and Robert F. Sprunger, "Analysis of the Accuracy of Pricing and Grading Wheat at Local Elevators," June 1957, both carried out under Purdue University A.E.S. Project 731.

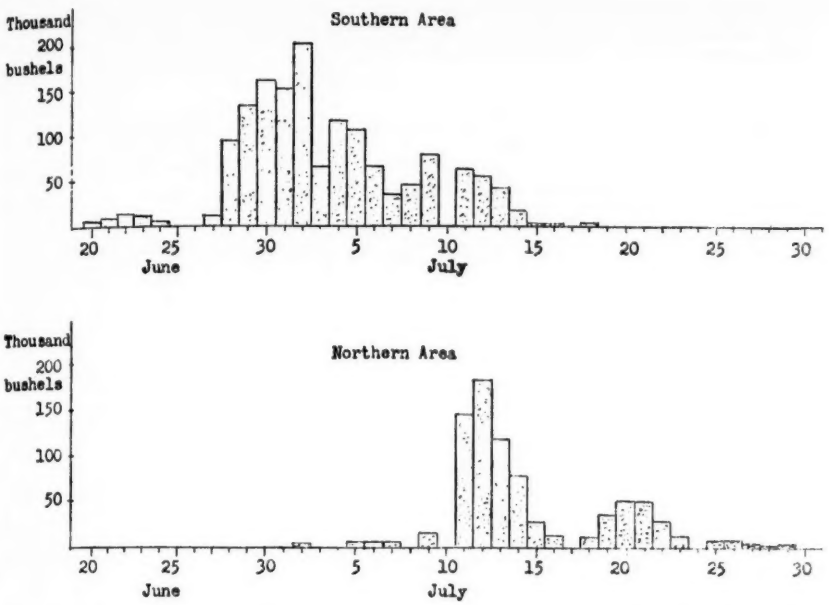

FIG. 1. DAILY VOLUME OF WHEAT RECEIVED BY COUNTRY ELEVATORS IN TWO INDIANA AREAS, 1955 WHEAT HARVEST SEASON.

short for performing the required marketing functions, including accurate pricing and grading.

Variations in Daily Paying Prices

In the northern area the widest price spread among elevators buying wheat on any one day was 8 cents, on July 13 (Table 1). The narrowest spread on any one day was 2 cents, on July 1 and 2. The average spread among elevators was 5 and 3 cents. In the southern area, the widest price spread among elevators buying wheat on any one day was 10 cents on July 12. The narrowest spread was 2 cents on June 25 and 29. The average spread among elevators was 4.5 cents.

Elevator paying prices within each area were averaged for each day during the period, July 5-16, 1955. These were days when elevators in both areas were buying in significant volumes. The daily average southern area price ranged from .9 to 3.2 cents per bushel higher than the daily average northern area price. For the entire period the southern area paying price averaged about 2 cents per bushel higher. Daily quoted paying prices during this season fluctuated around $1.80 per bushel.

Considerable variation existed even within counties. Within the southern area counties, a spread in daily paying prices of 3 to 4 cents was not

TABLE 1. VARIATIONS WITHIN SELECTED INDIANA COUNTIES AND AREAS IN COUNTRY ELEVATOR PAYING PRICES FOR NUMBER 2 WHEAT, 1955 HARVEST SEASON

Date	Area and County								
	Northern Area				Southern Area				
	Entire Area	County			Entire Area	County			
		Kosciusko	St. Joseph	Elkhart		Davies	Gibson	Knox	Sullivan
	Cents per bushel difference (maximum)								
June									
20					4		4	0	
21					4	0	1	2	3
22					4	0	1	2	3
23					4	0	1	2	3
24					5	2	2	2	3
25					2	0	2		
26									
27					4	0	1	4	1
28					4	1	1	0	0
29					2	1	1	1	1
30					3	2	3	2	1
July									
1	2	2			6	1	2	5	2
2	2	2			5	1	1	4	2
3					4			0	4
4					4	2	2	4	2
5	5	3	5	0	5	2	1	3	3
6	6	4	2	5	5	3	3	3	3
7	5	4	1	3	5	2	2	3	3
8	3	3	1		5	6	4	6	1
9	6	4	3	0	7	0	1	6	1
10									
11	5	4	4	2	7	0	2	6	2
12	7	6	4	2	10	4	2	4	4
13	8	5	6	3	8	0	4	2	4
14	7	4	5	1	4	1	1	1	3
15	6	2	5	1	5	1	3	0	2
16	6	2	3	1	5	1	3	0	2
17									
18	7	4	3	1	4		1	2	2
19	5	2	3	1					
20	5	2	3	1					
21	3	2	1	2					
22	4	2	1	2					
23	4	2	3	3					
24									
25	3	1	3	3					
26	4	2	3	4					
27	5	2	2	4					
28	6	2		1					
Season Weighted Average Paying Price Difference	6.0	4.2	3.5	1.4	3.6	3.1	.8	3.6	1.3

uncommon. In the northern area, the spread within counties reached 5 cents several times.

Special notice was taken of all towns in the two areas which had two or more elevators buying wheat (Table 2). It was expected that daily paying prices quoted by elevators in the same town would be the same. However, some variation was found. In the southern area, the maximum difference in any town on any one day was 4 cents. In the northern area the maximum difference was 6 cents. In only one of the towns with two or more elevators, Town C, was one elevator high on all days when a difference existed.

The fact that the widest spread in daily paying prices among elevators occurred in both areas from July 5 to July 14 might be explained by the sharp rise and drop in wheat prices during the 10-day period. The amount

of price spread among elevators in an area could result from variations in the amount of time required to transmit market information during a period of rapidly changing prices.

TABLE 2. VARIATIONS WITHIN SELECTED INDIANA TOWNS IN COUNTRY ELEVATOR PAYING PRICES FOR NUMBER 2 WHEAT, 1955 HARVEST SEASON

Date	Town									
	Northern Area							Southern Area		
	A	B	C	D	E	F	G	H	I[a]	J
	Cents per bushel difference[b]									
June										
24									0	
25										
26										
27								0	0	
28								1x	0	
29									0	1x
30								0	2y	1x
July										
1								0	0	0
2								0	0	0
3									0	
4								0	0	
5	0		2x					2x	0	0
6	1x	4x	3x		5x			0	3y	0
7	1y	0	2x		1y			2x	2y	2y
8	2x	3x	1x		2x			0	4y	1x
9	1x	1x	4x		0			0	0	1x
10										
11	2x	4x	0	2x	0	0	0	0	1z	0
12	1y	2x	0	1x	0	0	2x	2y	0	4y
13	1y	2y	2x	1x	2y	3x	1y	0	2z	2y
14	1x	3x	0	0	0	0	0	1y	1x	2y
15	0	4x	0	1y	0	1x	0	1y	0	
16	0	4x	0	3y	1y	1x	0		0	
17										
18	0	4x	1x	1x	6y	1y	0		2x	
19	2y	3x	1x	1x	0	1x	0			
20	2y	3x	0	0	0	1x	0			
21	0		1x	1x	0	2x	1y			
22	0		0	0	0	1x	0			
23	0		0	1x	1x	1x	0			
24	1y									
25	0		0	1x	1x	1x	2x			
26	2x		0	2x	0	1x	2x			
27			1x			1x	0			
28						1y	1x			
29						1y	0			
Season Weighted Average Paying Price Difference	0.9y	1.9x	0.2x	1.2x	0.2y	0.1y	0.7y	3.0x	1.9y	0.8x

[a] Three elevators were buying wheat in Town I. In each of the other towns included in this table, two elevators were buying wheat.

[b] In all towns except C, the price paid by a given elevator was not always high or low when a difference existed. Therefore elevators were arbitrarily labeled x and y, and the letter corresponding to the high paying elevator is given beside the price difference. For example, in Town A, elevator x paid 1 cent per bushel more than elevator y on July 6. On July 7, elevator y in Town A paid 1 cent per bushel more than elevator x. In Town I the three elevators are labeled x, y and z.

In two other studies, it was found that differences in elevator quoted prices for wheat, corn and soybeans tended to diminish as the harvest season progressed.[6] This study does not disprove the general tendency toward less spread as the harvest season progresses, but it does advance the hypothesis that large spreads are associated with fluctuating prices.

Season Weighted Average Prices and Margins

Season weighted average paying prices (weighted by bushels purchased) for these elevators also revealed differences as high as 6.0 cents in the northern area and 3.6 cents in the southern area. Within counties differences among elevators ranged from .8 to 4.2 cents per bushel (Table 1). Within the same town, differences between elevators were as high as 3.0 cents.

Season weighted average gross margins (differences between season weighted average paying and selling prices) for elevators in the northern area were inversely correlated with paying prices, but the relationship was not close ($r = -.51$). Margins for northern area elevators ranged from 3.7 to 11.0 cents per bushel, the majority falling between 6 and 8 cents. There was some variation by location. The average margins by counties were 6.1, 7.3 and 8.4 cents. Elevator selling prices, and therefore margins, were not available in the southern area to make a similar analysis.

Certain factors appeared to be associated with season average paying prices. Elevators which bought relatively large volumes of wheat were generally those with relatively high paying prices, and, in the northern area, low margins. Also, elevators with grain buying and selling a major portion of their businesses took lower margins and paid higher prices to farmers than elevators which concentrated on other lines of business.

In terms of gross sales, elevators with low margins and high paying prices were in the middle group. But there was an indication that some elevators with high gross sales were in a competitive situation which enabled them to pay lower prices.

A large amount of wheat shipped by truck in the northern area was associated with high margins, but elevators which shipped by truck generally received higher selling prices, and the total effect on paying prices was very slight. Differences in railroad freight rates, depending on elevator location, railroad carrier available, and shipment destination, appeared in a few cases to have some influence on elevator paying prices,

[6] W. G. Robinson, "An Analysis of the Effects of the Operation of Country Elevators Upon the Prices Paid for Wheat and Corn in Indiana," unpublished M.S. Thesis, Purdue University, 1955, and D. E. Meyers, "Soybean Price Variation Factors Among Indiana Elevators," unpublished M.S. thesis, Purdue University, 1953.

but this influence was overshadowed by the effects of other variables, such as factors affecting margins and local competitive situations.

Within the southern area, the line elevators were a major influence in the pricing structure. Paying prices for line elevators were set at the central office, and other elevators in the area tended to follow. The fact that line elevator paying prices averaged slightly higher than prices at other elevators in the southern area may be related to the general upward trend in wheat prices during the 1955 wheat harvest season. Other elevators lagged somewhat behind the line elevator price changes.

Over-all Evaluation

There were frequent day-to-day variations of several cents per bushel in elevator paying prices. But no elevator consistently paid a high or low price throughout the season. The tendency was for prices paid by all elevators in an area to be grouped together. The general level of prices tended to follow wheat futures prices.

Insofar as short run paying price fluctuations among elevators result from lags in the transfer of information and other imperfections caused by a general lack of market knowledge, the outlook is for improvement. The development of more rapid communications, improved pricing and marketing information, improved transportation facilities, and increasing alertness by farmers should help further to reduce price variations resulting from these imperfections.

Grading and Price Discounting

This part of the study deals with the second phase of price discovery, that is "determining the value of a specific lot of the commodity being exchanged relative to the general market level." For wheat there are really two separate functions involved in the second phase: (1) selecting a representative sample from each load received by the elevator, and (2) accurately determining the grade and price discount for each sample selected.

In this study no attempt was made to determine whether the wheat sample drawn by the elevator was representative of the load. The analysis is based on the grading and price discounting of the sample drawn by the elevator. In most cases it was believed that the magnitude of possible error in drawing a representative sample from a load of wheat was less than the magnitude of possible error in grading and price discounting a particular sample. But insofar as the possibility of not drawing a representative sample did exist, there was this additional source of inaccuracy in the second phase of price discovery.

Sampling Procedure

Clusters of elevators were selected from the same areas used in the study of quoted paying prices. Thirty wheat samples of approximately a half-gallon each were obtained from each of 12 elevators in the northern area and 11 elevators in the southern area. Seventeen samples were obtained from each of the two remaining elevators in the southern area.

The samples were taken from the loads in the order that they came in from the farms until the required number was obtained. The sample taken for testing in the laboratory was either the same sample that the elevator tested or a duplicate sample that was obtained by drawing a double amount and splitting it with a Boerner divider.[7] The samples were put in glass jars and sealed to maintain moisture content until tests were made later the same day. When each sample was obtained, a record was taken of the elevator's test determinations and price discounts. In addition, a short questionnaire was filled out concerning each elevator's operation.

After all samples for an elevator had been obtained or at the end of the day, a suitable place was found where test weight and moisture were determined for each sample by the standard procedure, using portable equipment from the Purdue Agronomy Laboratory. The samples were then put into paper bags and brought back to the Agronomy Laboratory, where tests were made for foreign material, damage, garlic, smut, and other grading factors.

The standard procedure that is prescribed by the Official Grain Standards was used to make the laboratory tests. The discounts were then determined for the laboratory findings by using the same discount schedule used by the elevator. Statistical analyses are based on the differences between elevator and laboratory grade determinations and price discounts.[8]

Grading Determinations and Comparisons

Test Weight. The standard deviation of the laboratory-elevator differences in test weight determinations was computed for samples from each elevator. In the northern area the standard deviations ranged from .42 to .91 pound. The mean difference for individual elevators ranged from minus 1.35 to plus 1.01 pounds (Table 3). A minus sign indicates the

[7] The Boerner divider is used in standard grain inspection procedure to divide grain samples into representative portions.

[8] It is believed that the laboratory determinations were made with a high degree of accuracy and consistency. Procedures used in obtaining and testing the samples were established with the assistance of David A. Sander, Instructor in Commercial Grain Quality, Purdue University Agronomy Department. The grading was done by Robert Sprunger under the supervision of Sander.

TABLE 3. TEST WEIGHT COMPARISONS BY KIND OF TEST WEIGHT MEASURE USED BY ELEVATOR, 1956 INDIANA WHEAT HARVEST

Kind of Test Weight Measure	Elevator	Type of Organization	Samples Taken	Comparisons: Samples Tested by Elevator	Laboratory Findings[a]: Lower	Higher	The Same	S_d[b]	S_D[c]	Mean[d] Difference	Significance Level[e]
			Number of Samples					Pounds			Per cent
Northern Area											
Pint (4-1)	O	Independent	30	30	30	—	—	.58	.10	−1.35	1
	T	Independent	30	30	13	13	4	.48	.09	+ .01	[f]
Quart	N	Cooperative	30	30	4	26	—	.61	.11	+ .53	1
	P	Cooperative	30	—	—	—	—	—	—	—	—
	Q	Independent	30	30	—	28	2	.42	.08	+ .73	1
	R	Independent	30	30	3	25	2	.61	.11	+ .58	1
	U	Cooperative	30	30	6	20	4	.74	.13	+ .48	1
	V	Cooperative	30	30	6	23	1	.73	.13	+ .43	1
	W	Independent	30	30	8	22	—	.78	.14	+ .42	1
	Y	Cooperative	30	30	12	17	1	.66	.12	+ .20	10
Half-gallon	S	Independent	30	30	—	30	—	.69	.13	+1.01	1
	X	Independent	30	30	19	10	1	.91	.17	− .54	1
Southern Area											
Pint (4-1)	G	Line	30	30	14	15	1	.43	.17	− .20	10
	K	Independent	30	30	14	13	3	.60	.11	+ .05	[f]
Quart	B	Independent	30	2	—	2	—	—	—	—	—
	C	Cooperative	30	30	7	19	4	.74	.13	+ .28	5
	D	Cooperative	30	—	—	—	—	—	—	—	—
	F	Independent	17	17	1	15	1	.39	.09	+ .41	1
	H	Independent	30	30	2	23	5	.46	.08	+ .25	1
	I	Independent	17	—	—	—	—	—	—	—	—
	J	Line	30	30	16	11	3	.53	.10	+ .03	[f]
	L	Independent	30	30	9	19	2	.45	.08	+ .15	10
Half-gallon	A	Independent	30	—	—	—	—	—	—	—	—
	E	Line	30	30	7	21	2	.62	.11	+ .28	5
	M	Line	30	30	12	16	2	.53	.10	+ .09	[f]

[a] The quart size test weight measure was used to run the laboratory tests.
[b] S_d = Standard deviation of the differences.
[c] S_D = Standard deviation of the mean difference.
[d] Average of the difference of laboratory findings minus elevator findings. − indicates laboratory findings lower, + indicates laboratory findings higher.
[e] Determined by the paired method with t test of the hypothesis that the mean difference is zero.
[f] Not different at or above 10 per cent level of significance.

laboratory findings were below elevator findings and a plus sign indicates laboratory findings were above elevator findings.

In the southern area the standard deviation of the differences ranged from .39 to .93 pound and the mean differences ranged from minus .20 to plus .41 pound.

Moisture. The standard deviation of the laboratory-elevator differences in moisture readings ranged from .30 to .59 per cent for elevators in the northern area, and the mean differences ranged from minus .48 to plus .57 per cent (Table 4).

In the southern area elevators the standard deviation of the differences ranged from .49 to .88 per cent and the mean differences ranged from minus .86 to plus .30 per cent.

Garlic. Wheat samples in the southern area varied from no garlic to over 2,000 garlic bulblets per 1,000 grams of wheat. Half the samples obtained from the southern area contained garlic, and the average for those was more than 150 bulblets per samples (Table 5). Garlic was not a problem in the northern area.

TABLE 4. MOISTURE READING COMPARISONS BY KIND OF MOISTURE METER USED BY ELEVATOR, 1956 INDIANA WHEAT HARVEST

Area, Kind of Moisture Meter and Elevator		Type of Organization	Samples Taken	Samples Tested by Elevator	Comparisons: Laboratory Findings[a] Lower	Higher	The Same	S_d[b]	S_D[c]	Mean[d] Difference	Significance Level[e]
			Number of Samples					Per cent			
Northern Area											
Universal	X	Independent	30	30	19	11	—	.41	.07	−.08	f
Steinlite	N	Cooperative	30	30	3	27	—	.54	.10	+.67	1
	O	Independent	30	30	3	27	—	.38	.07	+.43	1
	P	Cooperative	30	25	22	3	—	.45	.08	−.34	1
	Q	Independent	30	30	24	6	—	.59	.11	−.34	1
	R	Independent	30	30	26	4	—	.36	.07	−.36	1
	S	Independent	30	30	25	5	—	.39	.07	−.35	1
	T	Independent	30	30	26	4	—	.34	.06	−.26	1
	U	Cooperative	30	30	26	4	—	.33	.06	−.48	1
	V	Cooperative	30	30	25	5	—	.30	.06	−.35	1
	W	Independent	30	30	23	7	—	.35	.06	−.25	1
	Y	Cooperative	30	30	18	12	—	.50	.09	−.04	f
Southern Area											
Universal	A	Independent	30	30	27	3	—	.51	.09	−.39	1
	B	Independent	30	30	6	24	—	.51	.09	+.30	1
	N	Independent	30	—	—	—	—	—	—	—	—
Steinlite	C	Cooperative	30	30	14	16	—	.77	.14	+.03	f
	D	Cooperative	30	30	16	13	1	.68	.12	−.32	5
	E	Line	30	30	27	3	—	.80	.15	−.80	1
	F	Independent	17	17	9	5	3	.88	.21	−.28	f
	G	Line	30	3	3	—	—	—	—	—	—
	I	Independent	17	11	11	—	—	.82	.20	−.86	1
	J	Line	30	30	20	10	—	.54	.10	−.20	5
	K	Independent	30	—	—	—	—	—	—	—	—
	L	Independent	30	30	20	9	1	.49	.09	−.10	f
	M	Line	30	—	—	—	—	—	—	—	—

[a] The Weston moisture meter (formerly known as Tag Heppenstall), used by federal grain supervisors and licensed grain inspectors throughout the United States, was used to run the laboratory tests.
[b] S_d = Standard deviation of the differences.
[c] S_D = Standard deviation of the mean difference.
[d] Average of the difference of laboratory findings minus elevator findings. − indicates laboratory findings lower, + indicates laboratory findings higher.
[e] Determined by the paired method with t test of the hypothesis that the mean difference is zero.
[f] Not different at or above 10 per cent level of significance.

TABLE 5. GARLIC DETERMINATION COMPARISONS BY TYPE OF ORGANIZATION, SOUTHERN AREA, 1956 INDIANA WHEAT HARVEST

Type of Organization and Elevator	Samples Taken	Samples Containing Garlic	Comparisons: Laboratory Findings Lower	Higher	The Same
		Number of Samples			
Cooperative					
C	30	4	1	3	—
D	30	7	—	7	—
Independent					
A	30	15	3	12	—
B	30	12	—	12	—
F	17	10	2	8	—
H	30	16	4	12	—
I	17	5	2	3	—
K	30	17	4	13	—
L	30	11	5	6	—
Line					
E	30	25	—	25	—
G	30	17	1	16	—
J	30	22	1	21	—
M	30	24	—	24	—

Most elevators used 150 grams of wheat to make the determinations and multiplied the results by six. None used a divider to split out the sample to make the test. Some discounted a fixed amount for garlic, when any was present, regardless of the number of bulblets. Since some discount schedules were established with maximum discounts for either 100 or 200 bulblets per sample, elevators did not determine the actual number per sample when it was in excess of the maximum discount on the schedule. Therefore, it was not possible in such cases to determine accurately the variation between elevator and laboratory findings.

Other Grading Factors. The other grading factors, such as total damage, foreign material, matter except other grains, and smut, were found to be of little importance. Only seven samples were discounted for any of these factors by the elevators. Laboratory findings indicated discounts for 71 samples, or slightly less than 10 per cent of the total number of samples. Most of the laboratory discounts ranged between 1 and 8 cents per bushel.

Protein content is a quality factor of considerable importance for hard wheats in some areas, but is not a source of price variation for soft red winter wheat in Indiana. None of the elevators made protein content determinations, and none gave consideration to possible variations in this factor in pricing.

Price Discount Comparisons

The mean differences in test weight, moisture, garlic, and other factors in Table 6 indicate the difference between laboratory and elevator discounts in cents per bushel, and the total of the mean differences of these factors equals the total discount mean difference. A plus value means that the laboratory indicated discount was higher than the actual elevator discount, and a minus value means that the laboratory indicated discount was less. The mean difference, range of differences and standard deviations of the differences are shown in Figure 2.

The most significant characteristic of differences in total discounts was the wide variation that existed among individual samples within elevators. A few of the discount differences for individual samples in the northern area were more than 10 cents per bushel, and in one instance, 17.5 cents (Figure 2). In the northern area as a whole, the mean indicated laboratory discount for individual elevators ranged from 4.02 cents per bushel more than the mean elevator discount to 3.18 cents per bushel less. For all samples in the area, the mean indicated laboratory discount was .12 cents per bushel less than the mean elevator discount. For four elevators, the mean indicated laboratory discounts were higher, and for eight elevators, lower.

The mean differences for the cooperative elevators ranged from minus

TABLE 6. COMPARISONS OF THE DISCOUNT FACTORS BY MEAN DIFFERENCE AND SIGNIFICANCE LEVEL FOR INDIVIDUAL ELEVATORS GROUPED BY TYPE OF ORGANIZATION, TWO AREAS, 1956 INDIANA WHEAT HARVEST

Area Organization and Elevator		Total Discounts		Test Weight		Moisture		Garlic		Other Factors
		Mean Difference[a]	Significance Level[b]	Mean Difference[a]	Significance Level[b]	Mean Difference[a]	Significance Level[b]	Mean Difference[a]	Significance Level[b]	Mean Difference[a]
		(cents)	(per cent)	(cents)	(per cent)	(cents)	(per cent)	(cents)	(per cent)	(cents)
Northern Area										
Cooperative	N	+4.02	1	+.05	[c]	+3.97	1			—
	P	− .57	10	+.23	5	− .80	5			—
	U	− .40	[c]	−.07	[c]	− .67	5			+ .33
	V	−1.92	1	+.02	[c]	−2.00	1			+ .07
	Y	− .18	[c]	−.25	[c]	+ .10	[c]			− .03
Independent	O	+1.23	1	+.73	1	+ .33	[c]			+ .17
	Q	− .55	[c]	−.55	1	0	[c]			—
	R	− .44	5	−.17	10	− .27	[c]			—
	S	− .67	1	−.70	1	—	—			+ .03
	T	+ .50	5	+.10	[c]	—	—			+ .40
	W	−3.18	1	−.38	[c]	−2.83	1			+ .03
	X	+ .83	[c]	+.13	[c]	+ .67	[c]			+ .03
Southern Area										
Cooperative	G	+3.80	1	+.33	1	+2.80	1	+ .37		+ .30
	D	+5.60	1	+.43	5	+ .80	[c]	+ .80	5	+3.56
Independent	A	+ .93	[c]	+.37	[c]	− .97	[c]	+1.23	5	+ .30
	B	+4.40	1	+.60	5	+2.23	5	+1.57	5	—
	F	+8.41	1	+.24	5	+4.18	5	+3.41	5	+ .59
	H	+2.53	1	+.03	[c]	+ .93	10	+1.57	1	—
	I	+1.82	5	+.47	5	—	—	+ .94	[c]	+ .41
	K	+1.77	1	+.37	5	+ .13	[c]	+1.07	1	+ .20
	L	+ .50	[c]	+.13	5	+ .30	[c]	+ .07	[c]	—
Line	E	+8.20	1	+.17	10	+ .27	[c]	+7.33	1	+ .43
	G	+7.06	1	+.80	1	—	—	+5.26	1	+1.00
	J	+4.80	1	+.26	1	—	—	+4.47	1	+ .07
	M	+6.47	1	+.37	1	+ .13	[c]	+4.67	1	+1.30

[a] Average of the difference of laboratory discounts minus elevator discounts. − indicates laboratory discounts less, + indicates laboratory discounts more.
[b] Determined by the paired method with t test of the hypothesis that the mean difference is zero.
[c] Not significant at or above the 10 per cent level of significance.

1.92 to plus 4.02 cents per bushel. Moisture was the main factor, the mean differences ranging from minus 2.00 to plus 3.97 cents.

The mean differences for the independent elevators ranged from minus 3.18 to plus 1.23 cents per bushel. With the exception of one elevator, test weight was the most important factor, and the mean difference range for the test weight was from minus .70 to plus .73 cents.

The standard deviation of the laboratory-elevator differences ranged from 1.10 cents per bushel to 4.31 cents per bushel for individual elevators in the northern area. This means that with a standard deviation of 4.31 there was roughly a probability of 68 per cent[9] that the price to the individual farmer would have been within plus or minus 4.31 cents of the laboratory standard or within a range of up to 8.6 cents of what his neighbors received. However, this left a fairly high probability (approximately 32 per cent) of even more variation, depending upon how the elevator happened to grade and discount each particular sample.

The greatest total discount difference for an individual sample in the

[9] Assuming a fairly normal distribution of differences. This seemed to be a reasonable assumption for most elevators (Figure 2).

southern area was 46 cents per bushel, and variations of 10 cents or more were frequent. In contrast with those in the northern area, all southern area individual averages were positive; in other words, each elevator, on

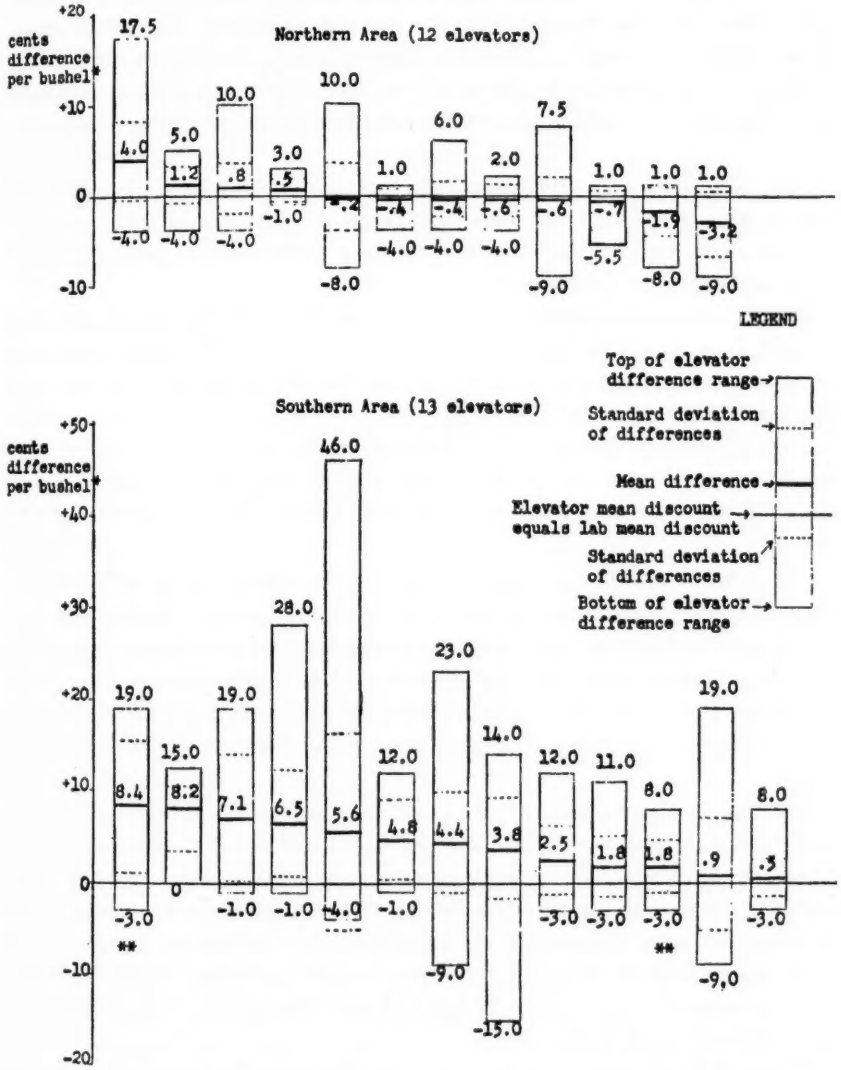

FIG. 2. DIFFERENCES BETWEEN ELEVATOR AND LABORATORY TOTAL DISCOUNTS BASED ON WHEAT SAMPLES FROM 25 INDIANA COUNTRY ELEVATORS, 1956 WHEAT HARVEST SEASON.

* Plus sign indicates laboratory discounts above elevator discounts. Minus sign indicates laboratory discounts below elevator discounts.

** Based on 17 wheat samples for each of these two elevators. All other computations based on 30 wheat samples per elevator.

the average, discounted less than was indicated by laboratory findings. Only one elevator discounted more than the laboratory for one factor, moisture. Even for this elevator, however, the laxity in discounting for other factors more than made up the difference, and the total laboratory price discount was greater than the elevator discount. The mean difference range was from 8.4 cents to .5 cents per bushel for individual elevators. For all samples in the southern area, the mean indicated laboratory discount was 4.33 cents per bushel more than the mean elevator discount.

The laboratory-elevator mean differences for the two cooperative elevators were plus 3.80 and plus 5.60 cents per bushel. Moisture was the important factor for one elevator; foreign material the most important discount factor for the other.

The laboratory-elevator mean differences for the independent elevators ranged from plus .50 to plus 8.41 cents per bushel. For a few elevators, moisture discounts were most important, but for most elevators the high discount differences were for garlic.

The laboratory-elevator mean differences for the line elevators ranged from plus 4.67 to plus 8.20 cents per bushel. Test weight and moisture were of little importance, garlic causing most of the difference in discounts.

The small variation in test weight and moisture can possibly be explained by the ideal weather and, consequently, the high quality of wheat being received during the sampling of the four line elevators. But of the samples obtained from the line elevators, more contained garlic than was found for the cooperative and independent elevators. Line elevators were even more lax on garlic discounts than other elevators in the southern areas.

The standard deviation of the laboratory-elevator discount differences in the southern area ranged from 2.13 to 10.69 cents per bushel for individual elevators. Therefore, even though all elevators graded more leniently than in the northern area, there was a great deal more variation in total discount differences. At most elevators a farmer faced a fairly high probability of 10 or 12 cents per bushel variation depending upon how his sample happened to be graded and discounted, and, of course, a possibility of much more.

There did not appear to be a relationship in either area between the amount of variation among individual samples within an elevator and the mean difference based on all samples for an elevator.

Summary of Grading and Price Discounting Study

In the northern area, the mean elevator price discount for all samples was only slightly more than was indicated by laboratory findings. Eight

of the 12 individual elevator discount difference means varied less than 1 cent from the mean indicated laboratory discounts. The discounts were made chiefly for moisture and test weight. Discount differences for moisture were in most cases greater and more variable than those for test weight.

In the southern area, the mean indicated laboratory discount for all samples was 4.33 cents greater than the actual elevator discount, and all elevators were more lenient on the average than was indicated by the laboratory. Leniency in grading and discounting for garlic was the chief reason, and this was particularly noticeable at the line elevators. Variations in moisture discounts were second in importance, and those in test weight, third.

Striking in both areas was the relatively wide variation in discount differences among individual samples within elevators. This appeared to be primarily the result of chance. For one farmer the variation in his total discount may have been caused by an inaccurate test, and for another, leniency in grading, or some combination of factors. Considering the rush conditions under which most wheat is received by country elevators, this is not surprising. The chance of error in pricing a load of wheat was increased further to the extent that samples drawn by the elevators were not representative.

No attempt was made in this study to determine whether there was a relationship between the level of individual elevator quoted paying prices and grading and discount practices. However, elevators which were most lenient in grading and discounting were in many cases the ones which quoted relatively higher paying prices in the study of quoted prices the previous year. This relationship was most obvious for the line elevators in the southern area.

The findings of these two studies do not appear entirely consistent. Yet, it was found that some elevators handle wheat on a small basis and only as a service to customers. Others are more concerned about buying wheat, either because they wish to maintain a large volume or they need it for milling purposes. Under such circumstances the combination of relatively high quoted paying prices and lenient grading and discount practices might be explained. Economies of scale associated with the vertical integration of the line elevators with the terminal processor could make such a situation possible.

The Demand Situation Facing Producers Under Pure but Not Perfect Competition

Though we have long known that the market for wheat at the country elevator level is not perfect, we have known little about the magnitude of the imperfections. This purely but imperfectly competitive market may

be illustrated diagrammatically as in Figure 3. The relative widths of the two bands undoubtedly would be different for other commodities, and even for wheat under various other conditions. The important point, however, is that the bands do exist. For a commodity less standardized than wheat there is good reason to expect the bands for both phases, but particularly for the second phase of price discovery to be even relatively wider than for wheat.

Monopsonistic influences can also be illustrated in Figure 3. If there were control by buyers but not by sellers, the demand schedule (or band) could still be horizontal within the range with which an individual farmer would be concerned, but the level of the band might be lower than if there were pure competition on both sides.

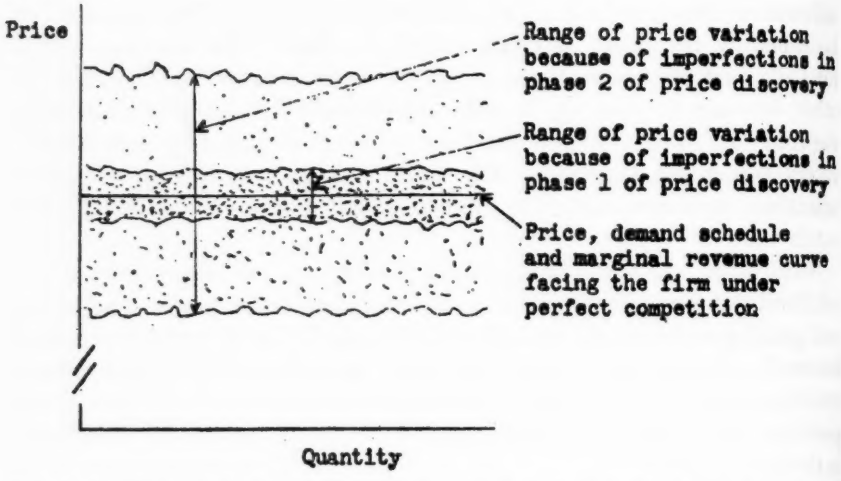
Price
Range of price variation because of imperfections in phase 2 of price discovery
Range of price variation because of imperfections in phase 1 of price discovery
Price, demand schedule and marginal revenue curve facing the firm under perfect competition
Quantity

FIG. 3. ILLUSTRATION OF THE DEMAND SITUATION FACING A FIRM UNDER PURE BUT NOT PERFECT COMPETITION.

Another observation is relevant. Even if *pure* competition on both the buying and selling sides is assumed, there could be opportunities for individual buyers and sellers to develop skills which could be used to their advantage in the market place. At just what price within the band one would expect the transaction to take place would seem to be the result of chance if the imperfections on the buying and selling side were about equal. But if one party were more skillful than the other, it would be expected that he could influence the location of price transactions within the band to his advantage.

A peculiar characteristic of the findings presented above is that although one would expect the elevator manager to be more skillful than

the farmer because of greater familiarity with grain buying, several actually discounted less on the average than was indicated by laboratory findings. Two explanations may play a part. In the first place, there was no way of determining whether the level of quoted prices, the first phase of price discovery, was lower than perfectly competitive conditions justified. Elevator margins, based on quoted prices, varied considerably, and it was not possible to determine what they would have been under perfectly competitive equilibrium conditions. To avoid farmer dissatisfaction, elevators were reluctant to discount grain, and many followed a practice of grading leniently. Such a practice would have been possible if quoted prices had been lower than perfectly competitive conditions justified.

In the second place, a country elevator is not only a place for farmers to sell grain but also a place to buy farm supplies. The country elevator has the constant problem of maintaining and building sufficient volume of business. The price paid for wheat, therefore, reflects not only supply and demand factors for wheat, but also efforts to attract sideline business. In such a situation the price actually paid for wheat is not paid just for wheat only. It is for wheat *and* "something else," the "something else" including a number of diverse things among which would be a certain amount of subjective feeling on the part of the elevator manager.

Implications

The question is raised whether, in our desire to make markets more perfect, we have underemphasized the second phase of price discovery relative to the first. Programs to expand market news and various kinds of current market information are needed and have been inaugurated for the first phase. But relatively less has been done to improve the grading and pricing of the actual commodities that flow through the channels of trade—the second phase of price discovery.

There appears to be considerable room for increasing the effectiveness of the pricing system for wheat at the country elevator level through more accuracy in grading and price discounting. The process now appears to overvalue low quality wheat and not adequately to reward producers of high quality wheat. Moreover, because of the uncertainty of not knowing just how accurately any particular sample will be graded and discounted, there is not likely to be a determined effort on the part of producers to deliver high quality wheat. If quality wheat is really preferred by terminal elevators and processors, the present grading and discounting methods and practices do not permit the pricing system adequately to reflect such preferences to producers.

There is a broader question. We commonly assume that the pricing process in most agricultural markets tends to yield results not greatly different from results under our theoretical ideal of perfect competition. This means, for one thing, that price can be relied upon to allocate resources. But if the empirical existence of a high or low price fails to indicate that more or less of a commodity of particular quality is demanded, the price signal to producers is not likely to call forth the quantities and qualities of products that consumers and the trade really want.

WHOLESALE AND RETAIL GROCERY MARGINS FROM THE 1952 OPS SURVEY*

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IN 1952 the Office of Price Stabilization conducted an extensive Food Margins Survey to determine wholesale and retail grocers' margins prevailing during early 1950. This survey was designed to secure reliable estimates of margins for all groceries subject to Ceiling Price Regulations 14, 15, and 16, for several other foods, and for many nonfoods sold by grocers. These results were desired as a basis for revising OPS regulations as necessary "to reflect generally fair and equitable markups."

The purpose here is to indicate the nationwide pattern of margins and to examine variations in such margins among commodities, sellers, regions, and certain other elements characterizing the food distribution industry. These data represent the first publication of nationwide margins of grocers. They can be used for several purposes. Major findings, to be discussed later, are:

1. Differences in 1950 margins were associated principally with two factors. Percentage markups varied widely among commodity categories and grocer classifications.[1] Generally, differentials by geographic regions, container sizes, and brand characteristics were either of relatively small magnitudes or inconsistent.
2. Definite positive correlations existed among margins used by the various seller groups. This means that commodities with high (or low) markups for one seller classification had correspondingly high (or low) margins for other grocer groups.
3. Considerable variability prevailed among margins of the individual observations sampled for separate commodity categories.

The information used for this study consisted of some 110,000 observations gathered from 400 wholesalers, 267 chain stores, and 78 independent

* Giannini Foundation Paper No. 168. Based on a report prepared by the author for the Office of Defense Mobilization: "Pre-Korean Margins for Food Distribution: An Explanatory Analysis of OPS Data," University of California, Davis, July 1954, ditto, 191 pp. (Contribution from the Giannini Foundation of Agricultural Economics). A full report and a complete statistical supplement is being published by the Giannini Foundation.

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[1] Generally "markup" signifies the difference between cost and selling price divided by cost, whereas "margin" may refer to this difference divided by either cost or price. Although the grocery trade commonly uses "margin" in this second sense, the two terms, "markup" and "margin," are used as synonyms throughout this paper—in conformity with usage in OPS regulations and in its Food Margins Survey—to represent the price-cost difference divided by cost.

retailers located in three metropolitan areas and 136 other cities. A three-stage probability sample was employed to select the cities, sellers, and items for the survey. Information for computing the percentage margin figures was obtained directly from the sample sellers' purchase and sales records.

Ceiling Price Regulations 14, 15, and 16 (issued by OPS on March 28, 1951) specified separate schedules of markups (over cost) for four wholesaler classes and four retailer groups. Each schedule provided average markups for 36 categories of dry groceries. The survey used the same seller classifications but divided commodities into about 80 categories such as breakfast cereals, coffee, and canned meats under foods; and cigarettes, soap, and insecticides under nonfoods.

Markups by Commodity Categories

The magnitude of differences among average margins for commodity categories can be illustrated by combining the wholesale and retail markups for any one of the major distributive outlets through which grocery products flow on their way to the housewife. Here we select the channel including cash-and-carry wholesalers and large chain retailers. These distributors' average 1950 margins are summarized in Table 1. They are arrayed separately for the 45 dry groceries and for the 22 nonfood products. Simple averages of category markups are shown to provide a measure of the difference in margins for dry groceries and nonfoods.

In this wholesaler-retailer sequence 1950 markups for only three nonfoods (cigarettes, soaps and strong cleaners) were below 35 per cent, the median figure on dry groceries. They exceeded 65 per cent on half the nonfoods and none of the dry grocery categories. Margins were very low, 11 to 16 per cent, for five commodity categories (sugar, canned milk, coffee, shortening, and cigarettes); averaged somewhat higher, 19 to 26 per cent, for soaps and eight foods; and varied from 26 to 50 per cent on two-thirds of the dry grocery categories and one-fourth of the nonfoods. They went as high as 50 to 65 per cent on four dry groceries and ranged from 50 to 100 per cent on 14 of the 22 nonfoods. Markups for the middle two-thirds of the commodity categories ranged from 22 to 46 per cent for dry groceries and from 34 to 78 per cent for nonfoods.

These data, although relating to only one channel of distribution, are similar to patterns secured for alternative marketing routes. During 1950, markups were considerably higher on nonfoods than on dry groceries. They varied widely among the individual categories within these two broad groupings.

Grocers seem to apply a wide range of markups rather than a single figure for establishing their selling prices. Apparently this variability in

TABLE 1. U.S. MARKUPS ON DRY GROCERIES AND NONFOODS IN 1950, BY COMMODITY CATEGORIES, CASH-AND-CARRY WHOLESALERS AND LARGE CHAIN RETAILERS (PER CENT OVER NET COST)

Commodity category	Wholesale	Retail	Total[a]	Commodity category	Wholesale	Retail	Total[a]
Dry Groceries				Corn meal	12.5	29.3	45.5
Sugar, granulated	1.6	9.7	11.4	Fruits, dried	11.8	30.2	45.6
Milk, canned	1.2	11.6	12.9	Fish, processed, other	12.8	29.4	45.9
Coffee, regular	3.3	10.1	13.7	Cookies, carton	12.6	30.3	46.7
Shortening	3.3	10.8	14.5	Miscellaneous groceries	11.6	31.6	46.8
Coffee concentrates	4.7	13.9	19.3	Fruits, canned, minor	15.3	27.5	47.0
Oleomargarine	5.1	13.8	19.6	Candy	11.6	35.5	51.2
Sugar, other	3.5	16.4	20.4	Pickles & relishes	17.3	31.6	54.3
Flour, family and enriched	6.7	15.2	22.9	Vinegar	20.7	32.1	59.4
Breakfast cereal, cold	4.8	17.5	23.2	Spices	16.0	41.9	64.7
Baby food, canned	4.9	17.9	23.7	*Nonfoods*			
Soup, canned	4.2	19.0	24.0	Cigarettes	4.0	11.6	16.0
Flour, other	6.2	17.6	24.8	Soap	3.9	16.5	21.1
Breakfast cereal, hot	5.9	19.1	26.1	Strong cleaners	7.6	23.3	32.7
Gelatin & puddings	5.9	21.4	28.6	Canning supplies	7.6	26.7	36.4
Flour mixes	5.7	22.1	29.1	Toilet paper & paper towels	11.3	27.3	41.7
Meats, canned	8.1	21.1	31.0	Matches	10.6	30.0	43.3
Oils, cooking & salad	8.4	21.0	31.1	Metal polish	7.1	37.0	46.8
Salmon & tuna, processed	7.2	22.5	31.1	Household laundry supplies	11.5	32.9	48.2
Syrups	5.9	24.3	31.7	Facial tissues	12.8	36.4	53.9
Dog food	5.6	25.1	32.0	Misc. paper supplies	14.7	34.2	53.9
Tea	6.6	24.4	32.6	Scouring pads	13.2	39.0	57.4
Peanut butter	6.7	25.1	33.5	Insecticides	14.5	47.7	69.1
Lard	12.2	19.1	33.6	Household polish & wax	12.4	51.4	70.1
Macaroni & spaghetti products	7.7	25.1	34.7	Work gloves	16.9	46.7	71.5
Baby cereal, dry	6.7	26.8	35.3	Brooms, etc.	20.4	43.5	72.7
Crackers	8.7	24.5	35.4	Glass cleaners	14.6	51.5	73.6
Soup, dehydrated	7.0	27.0	36.0	Sanitary napkins	14.8	52.3	74.8
Cocoa, chocolate, etc.	9.1	25.5	36.9	Spot removers	14.2	53.2	75.0
Mayonnaise, etc.	9.0	26.1	37.5	Deodorizers	12.4	57.7	77.2
Rice	9.6	27.7	40.0	Shoe polish	18.5	51.1	79.0
Fruits, canned, major[b]	12.9	25.0	41.1	Anti-insect equipment	20.5	53.2	84.7
Vegetables, canned, minor	11.8	26.8	41.8	Auto polish & wax	18.5	67.7	98.8
Jams, jellies & honey	10.7	28.6	42.4	Simple average, dry groceries	8.66	23.52	34.33
Vegetables, canned major[c]	13.9	25.1	42.5	Simple average, nonfoods	12.83	40.49	59.02
Vegetables, dried	9.0	32.5	44.5				

[a] Combination of wholesale and retail markups without adjustment for any differences between wholesaler's "selling price" and retailer's "net cost." Computations made from individual markups expressed to two decimal places.
[b] Canned fruit cocktail, pineapple, peaches and pears.
[c] Canned corn, green beans, peas, tomatoes, and tomato juice.
Source: Computed from data collected by 1952 OPS Food Margins Survey.

margins is one of the important means of competition among distributors. It cannot be explained simply in terms of a single factor. Rather the variation is the net resultant of several factors.[2]

Margins by Seller Classifications[3]

Average markups for 1950 and certain relationships among margins appear in Tables 2 and 3. These data indicate two things. Margins varied

[2] Investment in stocks is not an explanation since the margins used here are expressed as percentages. Bulkiness (i.e., demand on shelf space) does not provide an answer either. Some bulky commodities are among those with very low margins. Possibly rapidity of turnover provides the key. Certainly products with margins below 25 per cent move faster into consumption than most commodities with markups above 50 per cent. Yet some items with relatively high margins move rapidly—e.g., canned fruits and vegetables.

[3] Wholesalers were classified on the basis of the larger part of their food sales:

TABLE 2. WHOLESALE AND RETAIL GROCERS' AVERAGE 1950 MARKUPS (PER CENT OVER NET COST)

Seller classification	Mean[a]		Standard error of mean	
	Dry groceries	Nonfoods	Dry groceries	Nonfoods
Wholesaler				
Retailer-owned	5.68	8.63	0.362	0.563
Cash-and-carry	8.66	12.83	0.638	0.981
Service	10.54	15.32	0.679	1.255
Institutional	24.62	42.91	1.746	3.513
Retailer				
Large chain	23.52	40.49	1.044	2.967
Small chain	26.44	42.93	1.137	2.660
Medium independent	24.12	37.26	1.075	2.442
Small independent	24.55	36.64	1.049	2.157

[a] Simple averages of means for categories shown in Table 1.
Source: Computed from data collected by 1952 OPS Food Margins Survey.

widely among seller classifications. Differences in margins for one grocer group were related, more or less closely, with variations in markups for other sellers.

Generally markups were considerably higher for retailers and institutional wholesalers than for other wholesalers. Markups averaged 5.7, 8.7, 10.5, and 24.6 per cent on sales of dry groceries by retailer-owned, cash-and-carry, service, and institutional wholesalers. They were about one and a half times higher on nonfoods. Margins for small chains were almost three points higher than for large chains on both dry groceries and nonfoods. These differences are highly significant as can be seen from the t-ratios secured. Differences in markups for the two groups of independent retailers, however, were negligible and not significantly different from zero.

The survey did not secure representative data for independent retailers because a probability sample could not be used in selecting such sellers. OPS gathered data from those known to have records or to have followed practices that permitted ascertaining sufficiently reliable markups. Hence markup levels for independent and chain retailers can-

(1) retailer-owned cooperative—nonprofit organizations or corporations owned principally by independent retailers; (2) cash-and-carry—others not delivering sales except at a charge; (3) service—others making delivery to all customers without charge; and (4) institutional—others selling to commercial, industrial, or institutional users.

Retailers were grouped on the basis of sales volume in 1950 and number of stores under one ownership: (1) small independents—independents with sales under $75,000; (2) medium independents—independents with sales of $75,000-$375,000; (3) small chains—chains with sales under $375,000; and (4) large chains—all retailers with sales over $375,000. A food retail establishment was an "independent" store if it was a unit of one, two, or three stores under one ownership whose gross sales in 1950 totalled under $375,000. A "chain" store included all other food retailers.

not be compared. The data are useful, however, in determining other markup relations, e.g., variations among commodities and regions.

Data in Table 1 suggest strong positive correlation among wholesale and retail margins. The correlation coefficients given in Table 3 merely refer to the "best" linear relationships. They serve to indicate the tendency for low markups by one seller group to be associated with low markups by another group and for high margins to go together. No attempt was made to fit curvilinear regressions or to ascertain whether the possible inclusion of any "out-of-line" observations might be modifying or obscuring the "true" relationships.

We might consider one case for further comment. Fitting a linear relationship to the commodity margins appearing in Table 1 gives two equations:

$$Y = 12.18 + 1.27X \text{ for dry groceries, and}$$
$$Y = 9.95 + 2.38X \text{ for nonfoods, where}$$

X and Y denote margins for cash-and-carry wholesalers and large chain retailers, respectively. A fairly high degree of correlation existed, indicating that almost two-thirds (r^2) of the variation in margins at large chain stores is "explainable" by concomitant fluctuations in markups used by cash-and-carry wholesalers. An increment of 10 per cent in wholesale markups was associated, on the average, with 12.7 per cent in retail markups on dry groceries and 23.8 on nonfoods. The adequacy of the linear description is indicated by the scatterplots shown in Figure 1. Although

TABLE 3. RELATIONSHIPS AMONG GROCERS' 1950 MARKUPS

Seller classifications	Correlation coefficient[a]		t-ratios of mean differences[b]	
	Dry groceries	Non-foods	Dry groceries	Non-foods
Large and small chain retailers	.971	.954	10.51	2.69
Medium and small independent retailers	.931	.942	1.09	0.75
Cash-and-carry and service wholesalers	.873	.934	5.61	5.11
Cash-and-carry and retailer-owned wholesalers	.754	.833	7.03	7.02
Service and institutional wholesalers	.654	.418	10.06	7.08
Large chains and cash-and-carry wholesalers	.787	.789		
Large chains and service wholesalers	.731	.825		
Large chains and institutional wholesalers	.761	.547		

[a] For linear equations of form, $Y=a+bX$, fitted to observations for commodity categories listed in Table 1.

[b] Difference in means (Table 2) divided by the standard error of the mean difference. In computing the latter, the author gave recognition to the high positive correlations among markups for seller groups by using the standard formula for determining the standard error in such cases:

$$\sigma^2_{M_1-M_2} = \sigma^2_{M_1} + \sigma^2_{M_2} - 2\sigma_{M_1}\sigma_{M_2}r_{12}$$

Source: Computed from data collected by 1952 OPS Food Margins Survey.

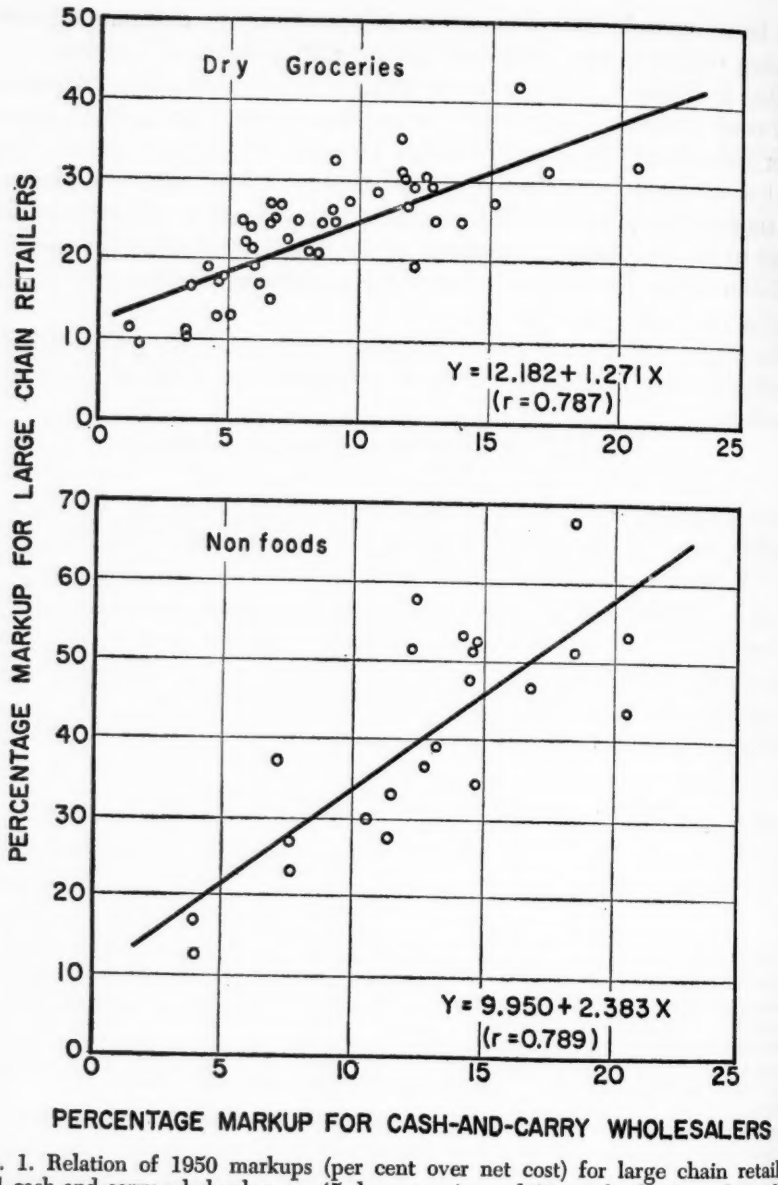
Dry Groceries
Y = 12.182 + 1.271 X
(r = 0.787)
Non foods
Y = 9.950 + 2.383 X
(r = 0.789)
PERCENTAGE MARKUP FOR LARGE CHAIN RETAILERS
PERCENTAGE MARKUP FOR CASH-AND-CARRY WHOLESALERS

FIG. 1. Relation of 1950 markups (per cent over net cost) for large chain retailers and cash-and-carry wholesalers on 45 dry groceries and 22 nonfoods. (Based on data given in Table 1.)

curvilinear relations may appear appropriate from a visual inspection of the data, the departure from linearity is not significant statistically—the adjusted correlation coefficients are actually reduced by the introduction of curvilinearity.

Intra-category Variability

Margins for individual sample observations within a commodity category were not dispersed about the central value in a consistent pattern. Frequently the distributions had a pronounced central tendency. Some of these unimodal distributions were reasonably symmetrical, while others were decidedly skewed, either positively or negatively. In several cases, however, the dispersion was definitely multimodal or rectangular. Distributions for six food categories, representing relative frequency of sales by large chain retailers made at varying markups, will illustrate the differences in dispersion obtained for 1950 margins.

The distribution for granulated sugar rose rapidly to its modal value and then declined more slowly with increasing margins. A slow increase to a peak value followed by a sharp decline prevailed for family flour. In the case of canned meat the distribution was fairly symmetrical. Here markups were below the modal, or typical, margin on approximately one-third, one-half, and three-fourths of the sales of sugar, canned meat, and flour, respectively. In all such unimodal distributions, of course, the modal markup can be determined easily. But the extent to which it is represented by the mean markup depends upon the manner in which the distribution of individual observations departs from normality.

The other distributions did not have definite central values. For canned soups the dispersion was decidedly bimodal. Markups tended to cluster about two separate values—15 and 20 per cent. About 75 per cent of the sales of spices and bulk cheese were spread out more or less uniformly over markups ranging from 20 to 50 per cent.

Other Factors Leading to Margin Differences

An important question remains: To what extent do markups vary because of the influence of factors such as geographic location, container size, and brand characteristic? Analysis of the 1952 OPS margin data indicates that some differences were associated with these factors. Markup differentials along regional lines, by container sizes and according to brand characteristics, however, do not reveal a consistent pattern of substantial and statistically significant differences.

The data shown in Table 4 indicate 1950 markups for dry groceries in the nine survey regions. Comparisons can be made as to differentials among geographic regions or between metropolitan areas and the surrounding states. Information for independent retailers and retailer-owned cooperative wholesalers is not shown, since margins were not available for a sufficient number of commodity categories in at least six regions for these two seller groups.

Generally, 1950 margins were higher in the North Central states and

TABLE 4. REGIONAL MARKUPS ON DRY GROCERIES, 1950 AVERAGES (PER CENT OVER NET COST)

Survey region	Wholesalers			Chain retailers	
	Cash-and-carry	Service	Institutional	Large	Small
Metropolitan areas[a]					
New York	5.6	7.7	26.4	21.8	27.0
Chicago		14.5		24.3	
Los Angeles		8.5	19.3	19.7	24.0
Geographical regions[b]					
Northeast	7.9	11.1	19.2	23.8	26.1
Southeast	5.9	10.4	20.8	21.8	24.1
Midwest	8.3	12.6	19.9	23.2	26.9
Northwest	10.0	11.0	20.4	25.8	25.1
Southwest		8.2	18.0	22.2	21.2
Far West	8.3	10.4	19.8	21.9	24.5

[a] The standard metropolitan areas used in 1950 by the U. S. Bureau of Census.
[b] Includes the following states, exclusive of the three metropolitan areas defined above:
Northeast—Conn., Del., Me., Md., Mass., N. H., N. J., N. Y., Penn., R. I., Vt., and Dist. of Col.
Southeast—Ala., Fla., Ga., Miss., N. C., S. C., Tenn., and Va.
Midwest—Ill., Ind., Ky., Mich., Ohio, W. Va., and Wis.
Northwest—Colo., Idaho, Iowa, Kans., Minn., Mo., Mont., Neb., N. D., S. D., Utah and Wyo.
Southwest—Ark., La., N. Mex., Okla., and Texas.
Far West—Ariz., Calif., Ore., Nev., and Wash.
Note: Blank spaces represent cases with too few observations for complete comparability in analysis.
Source: Computed from data collected by 1952 OPS Food Margins Survey.

lower in the Southwest than in other parts of the country. Among the metropolitan areas, margins appear to be highest in Chicago, lowest in Los Angeles, and at an intermediate level in New York. Margins were lower in Los Angeles than in the Far West and possibly lower in New York than in the Northeast. Markups, however, probably were higher in Chicago than in the Midwest.

This information suggests that margins were highest in the Great Plains and in the industrial belt stretching from Chicago to New York and lowest in the South. Regional differences in margins were substantial for some seller groups. There is little indication, however, of uniform variations. The contention that fairly definite regional differentials exist is considerably blurred by the conflicting evidence available relative to the 1950 period.

The Food Margins Survey was not designed to measure variations in markup differentials due to container size and brand characteristic. Yet some of the information gathered can be used to examine this problem. Possibly the best data available for this purpose are those relating to margins on canned fruits and vegetables. Markup differentials on these sales by chain stores and by wholesalers appear in Table 5.

Container size was defined by the net content of individual containers: (1) large size (over 16 ounces) and (2) small size (16 ounces or less). Generally a "large size" container holds two or three times as much as a "small size" container. With this classification the great bulk of most fruits and a large proportion of many vegetables are classified as large sizes. The resulting relatively thin sample of observations on small sizes tends to give some difficulty in making comparisons.

During 1950, percentage margins were definitely higher on chain store sales of canned fruits and vegetables in small containers. They were lower for only two of the 14 products listed—canned pears and green beans. The average differentials (2.03 and 4.90 percentage points for large and small chains, respectively) are statistically significant at the 1 per cent confidence level. A different result was obtained for service wholesalers. For these sellers, margins on small containers were lower on four products and higher on three. The average differential (either −1.54 for all seven prod-

TABLE 5. MARKUP DIFFERENTIALS FOR CANNED FRUITS AND VEGETABLES IN 1950, BY CONTAINER SIZE AND BRAND (PER CENT OVER NET COST)

Product	Container size[a]			Brand[b]	
	Service wholesalers	Large chains	Small chains	Institutional wholesalers	Large chains
Fruit cocktail	3.2	2.9	12.0	6.9	−2.5
Peaches	3.1	2.1	6.1	17.7	−2.8
Peas	2.8	−4.1	−5.8	12.5	−1.9
Pineapple	−3.1	4.9	3.7		−3.1
Apricots and cherries		5.5	7.6		−9.0
Other fruits		3.1	0.6		
Citrus juice		5.1	12.3	5.2	−3.1
Other fruit juices		0.1	1.0		−4.5
Baked beans		3.2	3.8		−1.4
Corn[c]				23.1	−1.2
Green beans		−1.2		−6.0	−3.7
Peas	− 0.6	2.5	7.1	2.7	2.2
Tomatoes		2.9		−1.3	−0.6
Other vegetables[d]	−15.2	0.2	5.5		
Tomato juice	− 1.0	1.2		22.8	−1.8
Simple average	− 1.54	2.03	4.90	9.29	−2.57
Standard deviation	6.01	1.84	4.95	9.81	2.03
Standard error of mean	2.27	0.49	1.49	3.47	0.56

[a] Markup for small size (16 ounces or less) minus markup for large size (over 16 ounces).
[b] Markup for private brand (one owned or exclusively controlled by distributor) minus markup for other brands.
[c] For canned corn the markup differentials by container sizes are −2.9, −0.6, and −5.4, respectively.
[d] Excludes catsup and tomato products.
Note: Blank spaces represent cases with too few observations for complete comparability in analysis.
Source: Computed from data collected by 1952 OPS Food Margins Survey.

ucts or +0.73 for the six products omitting "other vegetables" which has a large negative differential) is not statistically significant.[4]

These results are in conformity with expectations. Certainly at retail a higher percentage margin appears probable on small containers, since the retailer's handling costs are not proportional to value. For example, it takes about as much time to place a commodity on the shelf or handle it at the check-out counter whether the product is in a small or a large container. Wholesalers, on the other hand, handle canned fruits and vegetables in case lots. For them, approximately equal markups on small and large containers appear justified—at least from the cost basis.

A private brand was defined as one owned or exclusively controlled (within an area of operation) by a wholesaler or chain retailer. The comparison of markup differentials (Table 5) is limited to sales by institutional wholesalers and large chain retailers since these sellers are the principal grocer types using private brands extensively.

Margins on canned fruits and vegetables were 9.3 percentage points higher for private brands sold by institutional wholesalers and 2.6 points lower on chain store sales. Both of these average differentials are statistically significant—the t-ratios are 2.7 and 4.6—even though the variability about averages was considerable.

A comparison was made for nine other commodities (catsup, flour, coffee, jelly, marmalade, peanut butter, evaporated milk, margarine, and rice) sold in volume under private brands. For these products, margins were 3.7 and 4.1 percentage points higher on private brands sold by institutional wholesalers and chain retailers. The t-ratios for these mean differentials (2.1 and 1.3, respectively) indicate that markups on these products were significantly higher for private brands at wholesale but not at retail. These results agree with those secured for canned fruits and vegetables on sales at wholesale.

The retail grocery trade represented to OPS that higher markups must be allowed on commodities sold under the seller's own brand. It was argued that the distributor's costs are increased by expenses incurred for labelling, promotion, and extra warehousing. It was maintained further that the distributor's "net cost" figures would be lower than when the functions are performed by suppliers. There is no denying the validity of these two contentions. Their influence, however, seems to have been offset by the impact of other factors. Apparently the sales policy of sellers carrying house brands was aimed at increasing sales of such products via lower markups.

[4] Canned corn is excluded from these comparisons, since practically all sales (at retail) are in No. 303 and No. 2 vacuum cans. These two containers differ by only 2 ounces in net content and might be considered as of approximately equal size.

Conclusion

The margin control program used by OPS for establishing ceiling prices for wholesale and retail food grocers specified markup allowances which varied only by commodity categories and seller classifications. This study indicates these to be the two important factors producing variations in markups during 1950. Separate allowances on a regional basis do not appear justified. Possibly higher markups might be specified for retail sales of products in small containers and for wholesaler's private brands. The evidence obtainable from the OPS Food Margins Survey, however, is quite skimpy. Further study is necessary before it will be possible to say whether the markup differentials by container size and brand type apparent for canned fruits and vegetables also prevail for other items sold by grocers.

FUTURE OF IRRIGATION IN THE HUMID AREA

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Introduction

IRRIGATION in the 28 eastern humid states excluding Arkansas, Louisiana, and Florida increased a phenomenal eightfold in the decade ending in 1954 (Fig. 1). The irrigated acreage is only a fraction of the national total of 29.6 million irrigated acres reported for 1954, the last year for which census data are available. But these states have shown a greater rate of expansion in irrigated acreage than states in which irrigation has been more widely practiced. The increase for the three eastern humid states of Arkansas, Louisiana, and Florida was 91 per cent, while the 17 western states had a 39 per cent increase.[1]

Will irrigation in the humid area continue its rapid growth? How widespread will it become if recent or increased rates of expansion continue? What significant forces, such as possible water limitations, are likely to affect its future development?

Answers to these questions call for a review of the present status of irrigation in the humid area, an explanation of why it expanded so rapidly in the postwar era, and an analysis of competitive water uses, including future needs for irrigation. This provides the basis for a discussion of implications for the future.

Present Irrigation

This information was compiled and summarized from a special survey of irrigation in the humid area.[2]

Each state in the humid area reported irrigated acreage in 1954 (Fig. 1). Its widespread use in areas of only a few states, however, accounted for a large share of the total acreage of 587,978 irrigated in the 28 humid states.[3] The two leading regions, the Southeast and the Northeast, had approximately two-thirds of the total acreage.

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* The opinions expressed in this article, begun when the writer was employed by the Farm Economics Research Division, Agricultural Research Service, do not necessarily reflect the views of the U. S. Department of Agriculture. The author, now employed by the Foreign Agricultural Service, gratefully acknowledges the helpful suggestions for presenting the data on water resources by K. A. MacKichan, Geological Survey Water Resources Division, U. S. Department of Interior, Washington, D. C.

[1] For convenience of expression, the 28 eastern humid states are frequently referred to as "humid area" in this article.

[2] U. S. Bureau of the Census, U. S. Census of Agriculture: 1954, Vol. III, Special Reports Part 6, *Irrigation in Humid Areas* (Washington, D. C., 1956).

[3] Arkansas, Louisiana and Florida, not included in the humid area total, had about 2 million irrigated acres in 1954. Arkansas and Louisiana have large acreages of rice;

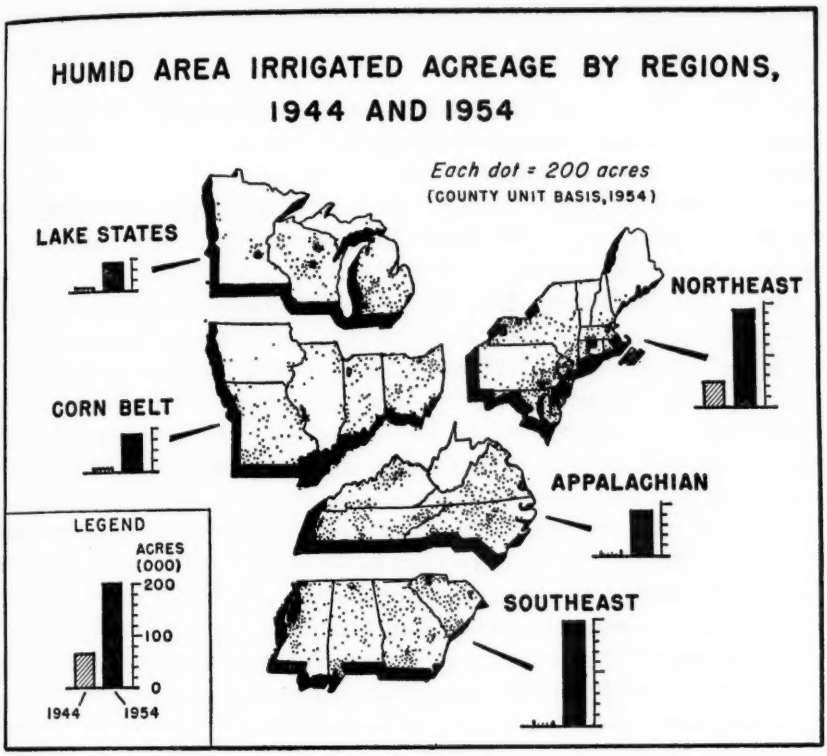

FIGURE 1

In the Southeast, Mississippi had more than 133,000 acres; this was the largest irrigated acreage of any single state in the humid area. In the Northeast, New York and New Jersey had more than 50,000 acres each. Other leading irrigated states included Missouri, North Carolina, Georgia, Virginia, Tennessee, South Carolina, and Michigan with an excess of 20,000 acres each.

Importance of Few Crops. Although approximately 130 different kinds of crops were irrigated in 1954, about three-fifths of the irrigated acreage was used for six crops: rice, Irish potatoes, pasture, corn, cotton, and tobacco. About 80 per cent of the total irrigated acreage was accounted for by 12 crops. In addition to the six listed, the 12 included hay, nursery and flower crops, tomatoes, snap beans, sweet corn, and "other vegetables."

A summary of 1954 irrigated crops by regions shows that, in the South-

in Florida, citrus and truck crop irrigation is practiced on a large scale. A total of 22,598 acres used for cranberry production, considered also as irrigated land, was not included in the humid area survey of irrigation.

east, the acreage of rice totaled about 70,000 and equaled 36 per cent of the total regional irrigated acreage. Cotton was grown on 22, pasture on 15, and corn on 8 per cent of the region's irrigated acreage.

In the Northeast, Irish potatoes accounted for 28 per cent of the acreage. Tomatoes, sweet corn, pasture, snap beans, and tobacco (chiefly in Connecticut) also used 28 per cent of the region's irrigated acreage.

Pasture, tobacco, corn, and hay including silage were the principal irrigated crops in the Appalachian region. These crops utilized 70 per cent of the region's irrigated acres.

In the Corn Belt states, 24 per cent of the irrigated land was in corn. The irrigated acreage devoted to rice, Irish potatoes, pasture, and hay including silage totaled 23,000 or 34 per cent of the registered total.

Irish potatoes grew on 39 per cent of the irrigated acres in the Lake States. Strawberries, nursery and flower crops, corn including sweet corn, snap beans, pasture, and hay including silage accounted for 29 per cent of the irrigated acreage.

Irrigation with Streams, Wells, and Sprinklers. Streams represented the principal source of water for irrigation in the humid area.[4] Water for more than 40 per cent of all farms reporting and approximately 37 per cent of the irrigated acreage was obtained directly from streams. Wells, the second most important source of water, were reported for 19 per cent of the farms and for nearly 24 per cent of the irrigated acreage. Springs, seepage, and surface runoff including farm ponds were reported by 18 per cent of those irrigating, but accounted for less than 9 per cent of the 1954 irrigated acreage.

Streams and wells were of approximately equal significance in acreage irrigated for all regions except the Appalachian and Southeastern regions. Streams represented the chief source of irrigation water in the Appalachian region; they were used to irrigate 73 per cent of the acreage. Springs and farm ponds were used for 16 per cent of the acreage while wells served only nine per cent. In the Southeast, wells were used to irrigate 57 per cent of the acreage and streams 36 per cent.

The most prevalent method for applying irrigation water in all regions was the portable pipe sprinkler system; for example, 52 per cent of the acreage in the Southeast, 98 per cent in the Appalachian region, and 78 per cent of the 14,541 farms reporting irrigation in the humid area relied on this system.

In the Southeast, flooding, ditches, and portable gated pipe accounted

[4] The sources of water and methods of application summarized in the irrigation survey were reported according to the major source or method with combinations with other sources or methods. The major sources and methods were exclusive of other major sources or methods; therefore, in the interest of brevity only the major source or method is referred to in this article.

for 47 per cent of the irrigated acreage. Also, approximately 12 per cent of the acreage of the Corn Belt states was irrigated by use of flooding and ditches.

Many Small Units Accounted for Little of Total Acreage. The most prevalent irrigation operation in the humid area in 1954 was small; it ranged from 1 to 9 acres per farm. Thirty-eight per cent of all operators reported irrigating 9 acres or less. Actually, the percentage irrigating small acreages was larger than was indicated by the special survey of irrigation, as the survey included only 64 per cent as many farms as were reported by the 1954 Census of Agriculture. Enumeration on a farm basis for the survey ranged from 31 per cent for Vermont to 84 per cent for Rhode Island. Farms whose operators irrigated from 1 to 9 acres ranged from 29 per cent of all farms in the Southeast to 48 per cent in the Appalachian region.

These small irrigated units accounted for an insignificant share of the total irrigated acreage in the humid area. Acreages irrigated in the 1- to 9-acre size group as a percentage of total irrigated acreage ranged from 2 per cent in the Southeast to 9 per cent in the Appalachian region.

Most of the irrigated acreage in the humid area (from 68 to 92 per cent) was accounted for by units on which 30 or more acres were irrigated. Large irrigated acreages were particularly evident in the Southeast, where approximately one-third of the acreage was in the 200- to 499-acre size group; one-fifth in the 500- to 999-acre group; and 10 per cent in the group with 1,000 or more irrigated acres.

On an acreage basis, the special survey of irrigation was more complete than on a farm basis. The survey included 93 per cent of the irrigated acreage reported by the 1954 Census of Agriculture.

Investment in Irrigation Systems. Operators who irrigated from 1 to 9 acres, the most commonly reported size, with portable-pipe sprinkler systems and used streams and lakes as the sources of water reported a per-acre irrigation investment of $415 (Table 1). Those who used wells had $436 invested per acre, while those who used springs reported $485 per acre.

As most of the irrigated acreage in the humid area was on farms whose operators irrigated 30 or more acres, investment per acre was much lower for acreages irrigated than might be inferred by the average investment for the more frequently reported small units. Farmers who relied on streams and lakes and irrigated 30 or more acres, for example, had per-acre investments ranging from $119 for 30 to 49 acres to $69 per acre for 200 to 499 acres.

For the many farmers in the humid area who practiced irrigation on relatively small acreages (1 to 9), investments in irrigation systems ranged

TABLE 1.—INVESTMENT COST PER FARM AND PER ACRE OF IRRIGATION SYSTEMS USING PORTABLE PIPE AND SPRINKLERS, CLASSIFIED BY NUMBER OF ACRES IRRIGATED AND SOURCE OF WATER, 28 HUMID STATES, 1955[1]

Acres irrigated (number)	Source of water					
	Streams and lakes		Wells		Springs	
	Dollars per farm	*Dollars per acre*[2]	*Dollars per farm*	*Dollars per acre*[2]	*Dollars per farm*	*Dollars per acre*[2]
1–9	1,985	415	1,863	436	2,636	485
10–19	3,206	240	4,058	298	3,893	296
20–29	3,886	169	5,144	222	5,117	217
30–49	4,270	119	6,238	169	6,557	181
50–99	6,640	102	10,262	149	10,069	150
100–199	9,728	79	15,061	132	16,356	133
200–499	19,571	69	24,962	123	25,564	108
500–999	31,750	48	21,000	41	—	—
Average	4,686	116	7,223	162	5,109	206

[1] U. S. Bureau of the Census, U. S. Census of Agriculture: 1954, Vol. III, Special Reports Part 6, *Irrigation in Humid Areas* (Washington, D. C., 1956), pp. XLVIII–XLIX.
[2] Per largest acreage irrigated.

from approximately $2,000 to $2,600 per farm. Operators who handled 30 to 49 irrigated acres reported investment costs for irrigation systems of $4,300 to $6,600 per farm.

Why Irrigation Expanded

The need for better distribution of water in the humid area for increased crop and pasture production has been recognized for decades. The development of drainage facilities in many areas was undertaken to fulfill this need. In addition, the adoption of irrigation systems, including the sprinkler system, more than three-quarters of a century ago, was designed to accomplish the same goal. The widespread adoption of irrigation in the humid states, however, did not get under way until the end of World War II. The basic changes that contributed to this development evolved over a long period of time. In the postwar era, they were manifested in improved sprinkler systems, high net returns from irrigation, and other developments including increased know-how.

Basic Changes. The earliest sprinkler irrigation (originally referred to as spray irrigation) in the humid area of the United States was an outgrowth of city lawn sprinkling. It was used chiefly for truck, nursing, and small fruit crops. During the second decade of the twentieth century, a method for "automatic oscillating" of an overhead sprinkling irrigation line (¾ to 1¼ inches in diameter) was developed. The hydraulic oscillator was designed for lines covering less than 10 acres. This technical innovation

eliminated the otherwise laborious hand labor involved in turning sprinkler pipes.[5]

"Spray" irrigation, however, remained a technically inefficient system as judged by today's performance standards and, therefore, an expensive system of operation. Its cost ranged from $150 to $300 or more per acre. Accordingly, it was confined largely to "protection" of the more valuable crops.[6]

It was not until the middle thirties, when further improvements were made in portable pipes, that the cost of sprinkler irrigation was reduced to competitive status with surface irrigation in the humid area. This reduction in cost was aided by the development of improved types of quick-coupling pipe devices invented in the 1920's and production of lightweight portable welded steel pipes that could carry the pressure needed. Hence, quick assembling and disassembling of a pressure-tight line of pipe was made possible.[7]

Improved Sprinkler Systems. Following World War II, the wartime sources of aluminum developed were freed for peacetime uses. The manufacture of irrigation pipe was included. The aluminum pipe that was developed weighed only about a third as much as the portable galvanized iron pipe previously used. Two 20-foot lengths of pipe, 4 inches in diameter and weighing approximately 15 pounds each, could easily be carried by one man. Although it was light in weight, the portable pipe was relatively durable and could withstand rough field treatment. The smooth interior surface permitted a minimum of friction loss, no painting or surface coating was necessary for maintenance, and aluminum irrigation pipe up to 6 inches in diameter was lower priced than other types. Further improvements including "quick-coupling" devices, along with improved motors, pumps, and fuels, were instrumental in improving performance of irrigation systems and enabling the scale of operations to be increased.

Net returns from Irrigation. Reduced production costs resulting from technological improvements combined with high product prices, especially in the immediate postwar years, resulted in favorable price-cost relationships for many irrigated crops.

The latter situation permitted high net returns from irrigation in many parts of the humid area. Irrigation of tobacco in Virginia in 1953, for example, resulted in a net increase of $282.00 per acre; irrigation of pas-

[5] "Suspension Method and Automatic Oscillating Device for Overhead Irrigation Systems," *Engineering and Contracting*, Vol. XLVII (January 10, 1917), pp. 35-36.

[6] F. W. Stanley, *Surface Irrigation for Eastern Farms*, Farmers' Bulletin 899, United States Department of Agriculture (Washington, D. C.: December, 1917), p. 3.

[7] F. E. Staebner, *Supplemental Irrigation*, U. S. Department of Agriculture Farmers' Bulletin No. 1846 (Washington, D.C.: October, 1940), p. 41.

ture for dairy production in Tennessee in 1953 resulted in a net increase of $102.36 per acre; and irrigation of cotton in Georgia in 1953 returned a net increase of $68.35 per acre (in Missouri the net increase was $242.32 per acre). Irrigation of potatoes on Long Island during 1938-45 increased the average yield over nonirrigated potatoes by 57 bushels per acre and increased net income by $50.96 per acre. In 1953, Missouri reported a net increase of $32.10 per acre from an additional yield of 43 bushels of irrigated corn.[8]

A further indication of the successes enjoyed by irrigators in the humid

TABLE 2. RESULTS OF HUMID AREA IRRIGATION REPORTS AND RESEARCH CLASSIFIED ACCORDING TO SELECTED CRITERIA[1]

Criterion	Percentage of total
Irrigation report showed:	
Increased yield	52
Increased net returns	13
Increased quality of product	6
Increased gross returns	4
Irrigation report showed:	
Costs	13
Yield and costs	3
Yield and returns	3
No response on yield	3
Yield, costs, and returns	1
Mixed response on yield	1
Decreased yield	1
Total	100

[1] The results are based on 75 selected annotated references from the *Bibliography of Agriculture*. The references included material published in November 1950 to January 1957. Some of the reports and research studies listed more than one criterion. The percentage figures, in effect, show the relative significance for each criterion.

area may be obtained from a look at the many articles that have appeared in the farm press and the research publications issued during the last six years. These articles presented results based on farmer experience and experimental research. In most instances, the results reported were favorable. A summary of a selected number of these references showed that 75 per cent of the information could be classified as: Irrigation increased yields, increased net returns, increased quality of product, and increased gross returns (Table 2). Only 5 per cent of the information indicated that humid area irrigation gave no response on yield, gave a mixed response, or resulted in a decreased yield.

Of particular significance in dramatizing the potential possibilities of high income from humid-area irrigation were the quick successes, easily

[8] Max M. Tharp and C. W. Crickman, "Supplemental Irrigation in Humid Regions," *"Water", the Yearbook of Agriculture, 1955*, p. 256.

verifiable, that occurred during a single crop season. Published articles extolling the record of these sudden achievements, as well as the observable and "word-of-mouth" community reports on the benefits of irrigation, among other things, were influential in stimulating increased expansion.[9]

Other Developments. In addition to improved technology, other significant developments speeded up adoption of humid-area irrigation: promotion of sales of irrigation systems by manufacturers, dissemination of technical information by public and private agencies, desire of producers to increase production as well as their hope of reducing uncertainty of low yields or crop failures, greater availability of capital funds for investment, and increased prevalence of droughts in many parts of the humid area.

Competitive Water Uses and Expanded Irrigation

Today, in many parts of the humid area, irrigation is increasingly practiced in normal as well as dry years. Although many factors will affect the rate and degree of future expansion of irrigation, water will be one of the major limiting factors.

Water Uses Exceed Physical Supply. The physical supply of water has a finite limit. For the 3 million square-mile area of continental United States, assuming an average rainfall of 30 inches, 4,300 billion gallons of water are produced per day. Of this 4,300 billion, approximately 70 per cent returns to the atmosphere by transpiration and evaporation, leaving a total amount of runoff in rivers and streams or percolating into the ground of about 1,200 billion gallons as the ultimate physical supply.[10]

This runoff of 1,200 billion gallons is the quantity of water available, within certain limitations, for future development of irrigation and other purposes. A chief limitation is that nearly two-thirds of this stream flow passes into the oceans as flood flow in a short period of time. Less than a third of the total stream flow is available during most of the year.

More than half—628.4 billion gallons daily—of the annual average runoff in the United States (the physical supply) occurs in the humid area. The quantity of water withdrawn (removed from the ground or diverted from a stream or lake) in the humid area exceeded the supply in the 1953-56 drought years by 73 per cent, because of re-use (Table 3). This

[9] During the course of an extensive field trip through New Jersey, New York, Connecticut, Massachusetts, and Pennsylvania in 1956 to obtain information on irrigation, the author observed that many "irrigation communities" currently existing, which depend on wells as the source of water, had developed over a relatively short period of time. The cost of drilling a well, coupled with the uncertainty of known water yields, were listed by many irrigators as original major deterrents. Once it was demonstrated that these forces were not too costly to be overcome in a given area, rapid expansion followed.

[10] Walter L. Picton, BSB-136, *Water Use in the United States, 1900-1975*, U. S. Department of Commerce (Washington, D. C.: January, 1956), p. 3.

TABLE 3. THE PHYSICAL SUPPLY OF WATER AND TOTAL WITHDRAWAL INCLUDING WATERPOWER IN MILLIONS OF GALLONS PER DAY AND PERCENTAGE OF TOTAL WITHDRAWAL IS OF FIXED SUPPLY, HUMID AREA REGIONS[1]

Region	Million gallons daily		Percentage total withdrawal is of 1953–56 supply
	Supply 1953–56 average runoff[2]	Total withdrawal including waterpower	
	Gallons	*Gallons*	*Per cent*
Northeast	205,700	406,188	198
Corn belt	72,700	87,825	121
Lake States	83,000	189,863	229
Appalachian	136,000	251,075	185
Southeast	131,000	151,647	116
28 Humid States	628,400	1,086,598	173

[1] Compiled from Geological Survey Circular 398, 1957, p. 13.
[2] Compiled from unpublished data of the U. S. Department of Interior. The supply for 1953–56 is based on drought years' availabilities of 628.4 billion gallons per day. For the years 1921–45, the average runoff (physical supply) for the humid area was 711.3 billion gallons per day.

pattern varied by regions. Withdrawal uses exceeded the supply most for the Appalachian region (85 per cent), the Northeast (98 per cent) and the Lake States (129 per cent). In the Southeast and Corn Belt regions, withdrawal uses were only 16 and 21 per cent, respectively, above their physical supplies.

In terms of quantity, waterpower represented the most important single withdrawal use of water in the humid area. Of a total of 1,086.6 billion gallons withdrawn for all purposes, a total of 984.6 billion gallons was reported as used daily for power.[11] Much of the water withdrawn is not consumed; as a result, the supply is not reduced by the amount withdrawn. Although no estimates are available as to the quantity of water used for such purposes as navigation, recreation, and conservation of fish and wildlife, these uses constitute a part of the total supply of 628.4 billion gallons available daily in the humid area.

Industrial and Public Water Uses Overshadow Irrigation. In the humid area, withdrawal of water for various purposes excluding waterpower totaled 101.9 billion gallons daily (Table 4). Most of the water withdrawn excluding that for waterpower was for self-supplied industrial purposes totaling 87.6 billion gallons daily and equaling 86 per cent of total withdrawal.

Water withdrawn for public use totaled 11.7 billion gallons and equaled 11 per cent of the total supply withdrawn daily, excluding water-

[11] Compiled from K. A. MacKichan, Circular 398, *Estimated Use of Water in the United States–1955*, U. S. Department of the Interior, Geological Survey Water Resources Division (Washington, D. C.: 1957).

power, for the humid area. Seventy-four per cent of the withdrawal for public use was in the Northeast and Corn Belt.

Water withdrawn for rural use in the humid area totaled 1.5 billion gallons daily, most of which consisted of water obtained from ground sources. It equaled a little more than 1 per cent of the total supply withdrawn for all purposes excluding waterpower.

Water used for irrigation totaled 1.2 billion gallons daily in the humid area and also represented only a small share of the total supply withdrawn for all purposes. Irrigation water, however, is in a different category from most other withdrawal uses, because more water is consumed (evaporated). This is especially true of sprinkler irrigation in humid states where, in some instances, consumption may amount to 100 per cent.

Rice a Major User of Irrigation Water. A total of 1,329.2 thousand acre-feet of water was used for irrigation in the humid area in 1955 as compared with 129.0 thousand in 1950 (Table 5). This was a ninefold increase in withdrawal of water for irrigation. The Southeast used 71 per cent of the water withdrawn for irrigation in the 28 eastern states in 1955; in 1950 it accounted for only 5 per cent. A major part of the increase was required because of an increase in acreage of rice and cotton in Mississippi. The water requirement for rice is especially high as compared with other irrigated crops because rice fields are submerged for three to five months during the year.

TABLE 4. WITHDRAWAL OF WATER IN MILLIONS OF GALLONS PER DAY, EXCLUDING WATERPOWER, FOR SELECTED USES, HUMID AREA REGIONS, 1955[1]

Region	Total withdrawal of water excluding waterpower	Self-supplied industrial							Public supplies		
		Ground			Surface			Total	Ground	Surface	Total
		Fresh	Saline[2]	Total	Fresh	Saline[2]	Total				
	Million gallons daily										
Northeast	32,629	1,145	23	1,168	16,567	9,043	25,610	26,778	696	4,724	5,420
Corn Belt	31,724	2,300	32	2,332	25,500	0	25,500	27,832	691	2,591	3,282
Lake States	13,863	600	25	625	11,600	0	11,600	12,225	370	924	1,294
Appalachian	16,075	790	0	790	13,600	450	14,050	14,840	201	745	946
Southeast	7,647	830	2	832	4,742	308	5,050	5,882	274	477	751
28 Humid States	101,938	5,665	82	5,747	72,009	9,801	81,810	87,557	2,232	9,461	11,693

Region	Rural			Irrigation			Total
	Ground	Surface	Total	Ground	Surface	Sewage	
	Million gallons daily						
Northeast	249	46	295	48	88	0	136
Corn Belt	386	148	534	33	43	0	76
Lake States	229	49	278	10	56	0	66
Appalachian	157	79	236	9	44	0	53
Southeast	105	63	168	486	360	[3]	846
28 Humid States	1,126	385	1,511	586	591	[3]	1,177

[1] Compiled from Geological Survey Circular 398, 1957, p. 13.
[2] Saline water is defined as water containing more than 1,000 ppm (part sper million) of dissolved solids regardless of composition of the solids and is not necessarily a salty (Nacl) water.
[3] Negligible.

TABLE 5. WITHDRAWAL OF WATER FROM GROUND AND SURFACE SOURCES PER YEAR FOR IRRIGATION, HUMID AREA REGIONS, 1950 AND 1955[1]

Region	1950			1955		
	Ground water	Surface water	Total	Ground water	Surface water	Total
	1,000 acre-feet	*1,000 acre-feet*	*1,000 acre-feet*	*1,000 acre-feet*	*1,000 acre-feet*	*1,000 acre-feet*
Northeast	74.0	9.0	83.0	55.0	98.5	153.5
Corn Belt	1.0	1.0	2.0	36.3	48.4	84.7
Lake States	8.0	23.0	31.0	11.4	61.7	73.1
Appalachian	3.0	3.0	6.0	22.0	49.1	71.1
Southeast	7.0	0.0	7.0	543.7	403.1	946.8
(Mississippi)	*	*	*	514.0	348.0	862.0
28 Humid States	93.0	36.0	129.0	668.4	660.8	1,329.2

[1] Compiled from Geological Survey Circular 115, 1951, pp. 6–7; and Circular 398, 1957, p. 8.
* Negligible.

In 1955, ground sources in the Southeastern states furnished 60 per cent of the water used for irrigation and surface sources supplied 40 per cent. For the combined 28 eastern states, each of these sources supplied 50 per cent of the irrigation water in 1955, because of the heavy use of ground water in Mississippi. Other than in the Southeastern states, surface sources were relatively more important in 1955 than in 1950. In the Northeast, less ground water was used for irrigation in 1955 than in 1950.

Future Irrigation Water Requirements. Projections (not forecasts) for three future levels of irrigation in the humid area for 1964 and 1974 have been developed (Fig. 2 and Table 6). These projections were developed to appraise the amount of water required in the event irrigation continues to increase as well as to estimate the probable production impacts of expanding irrigation. The projections were based on recent trends in irrigated acreage and water application adjusted for expected long-run changes in demand for farm products.[12]

The rapid increase in irrigated acreage for the humid area as a whole from 1944 to 1954 also characterized each of the five regions (Fig. 2). Beginning with the lowest acreages in 1944, the Southeast and Appalachian regions experienced the most rapid increases to 1954. In the Corn Belt, Lake States, and Northeast, the rate of increase was not as great as for the less-established regions which irrigated smaller acreages in 1944. If similar forces apply in the future as in the past, future rates of expansion for the area as a whole might be less rapid than they were during the last decade as some parts of the area are now more developed than in 1944.

[12] No increase in acreage of rice—the major user of humid area irrigation water to date—was assumed, as the long-run demand for rice does not indicate a need for an increase in production. See Rex F. Daly, "The Long-Run Demand for Farm Products," Vol. III, No. 3, *Agricultural Economics Research* (July, 1956), pp. 73-91.

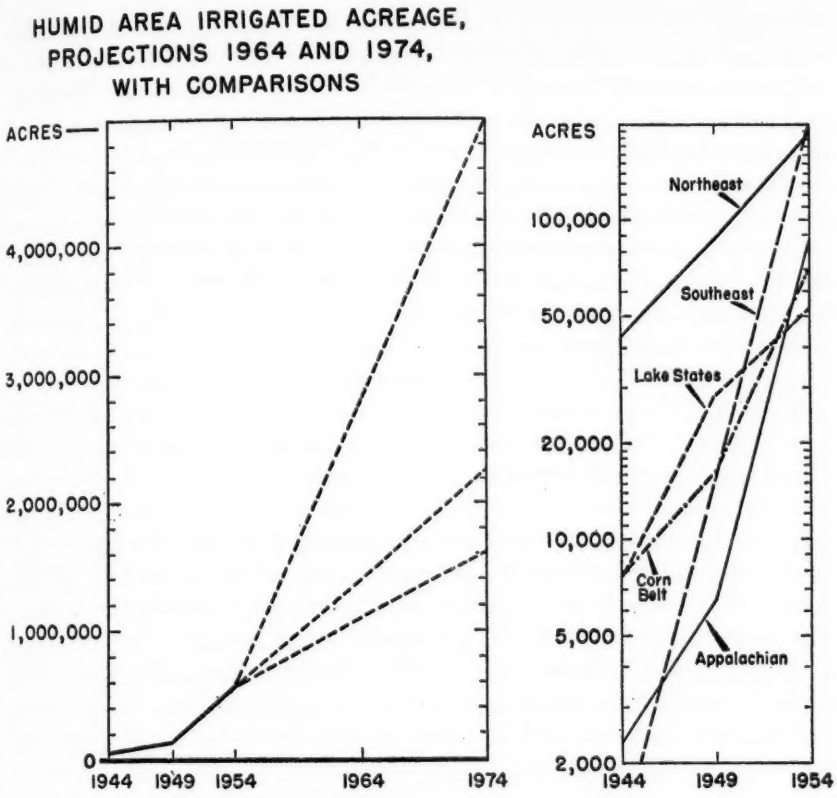

FIGURE 2

On the other hand, a continuation of the tendency to add irrigation in line with the trend toward increased agricultural efficiency might bring about a rate of increase similar to the rates of 1944-54 or 1949-54.

Based on the 1944 to 1954 rate of increase, projected irrigated acreages would range from 1.1 million acres in 1964 to 1.6 million by 1974 (Fig. 2 and Table 6). The projected quantity of water needed would be from 1.5 times to almost double the quantity of water used in 1955.

TABLE 6. ESTIMATED QUANTITIES OF IRRIGATION WATER REQUIRED BASED ON PROJECTED IRRIGATED ACRES, HUMID AREA, 1964 AND 1974

Item	Projections					
	1964			1974		
	Million	*Million*	*Million*	*Million*	*Million*	*Million*
Acres	1.1	1.4	2.8	1.6	2.3	5.0
Water*	1,785.0	2,096.0	3,473.0	2,307.0	2,927.0	5,658.0

* Gallons daily.

Assuming that irrigation in the humid area will expand at the more rapid rate characteristic of the five-year period 1949 to 1954, a total of 1.4 million acres would be irrigated by 1964; while 2.3 million acres would be irrigated by 1974. From 1.8 to 2.5 times as much water would be needed as was used in 1955.

Although it seems unlikely that the rate of future increase will be in excess of the recent rapid rises, the existence of very favorable price-cost relationships could act as a stimulant to further development. If the irrigated acreage should increase to 2.8 million and 5.0 million acres, respectively, by 1964 and 1974—double the acreage levels that would be irrigated in these years if irrigation increased at the same rate as for 1949-54—from 3 to 4.8 times as much water would be used for irrigation as in 1955.

If the highest projection of 5 million acres were to be realized, humid area irrigation would still be relatively insignificant; it would equal less than 3 per cent of the cropland acreage in the humid area.[13] Furthermore, based on current total withdrawals, irrigation in the humid area would use only a small amount of the water withdrawn. However, the quantity of water required to irrigate the projected acreages would call for sizable increases in quantity of irrigation water over that presently used. These quantities would equal 1.5 to 4.8 times the quantity of water used for irrigation in the eastern states in 1955. If the highest projection were realized, the increase would still be less than the ninefold increase from 1950 to 1955. But it should be noted that the increase from 1950 to 1955 was added to the relatively small total for 1950.

Implications

For the future, continued advancements are expected in farming efficiency. This, along with further technological improvements, would cause additional expansion of irrigated acreage, provided price-cost relationships were favorable.

Another factor conducive to an expansion of irrigated acreage is the

[13] One writer states that the most optimistic do not project over 8 to 12 million irrigated acres for the 31 eastern states in the forseeable future. See Elco L. Greenshields, *Trends and Economics of Irrigation in Humid Areas*, U. S. Department of Agriculture (Washington, D. C.: October 15, 1956), p. 2.

In 1954 the 31 eastern states had an irrigated acreage of 2,581,466. Twenty-eight of the states (the "humid area" referred to in this article) had a 1954 acreage of 587,978 and showed an eightfold increase in acreage for the decade ending in 1954. Three states, Arkansas, Louisiana, and Florida, had a 1954 acreage of approximately 2 million and showed about a 100 per cent increase in acreage for the decade ending in 1954. Assuming that the same increase (2 million per decade) for the three states was to continue for the following two decades, their total irrigated acreage would be 4 million by 1964. This would leave from 4 to 8 million acres for the other 28 states. By 1974 the three states would have an irrigated acreage of 6 million. This would leave from 2 to 6 million acres for the other 28 states.

tendency to increase production of food, fiber, and tobacco from more intensive use of land rather than from increased cropland. Most purchases of land by farmers for farm enlargement were brought about in large part by the increase in size of acreage that could be handled by modern machinery. The decision as to whether to enlarge the farm by adding land or by other means that would enable greater intensification depends on the marginal return expected from the alternatives available. In the last decade, irrigation has offered a more favorable prospect in many instances than could be obtained from investment in additional land. With increased limitations on available cropland in the future, and continued farm enlargement (increase in size of business) in prospect, along with producer desire to reduce uncertainty from the over-all farm operation, further inducements to irrigation seem apparent. In general, most of the expanded acreage is expected to be irrigated with sprinkler systems rather than with other methods, because of the advantage of using sprinklers on uneven terrain.

Expansion of High-Value Crops and Livestock Production. Estimates of the demand for farm products by the Agricultural Marketing Service of the Department of Agriculture for 1960 and 1975—based on the major assumption that the economy will grow much as it has during prior decades—reveal that total demand for farm products will depend chiefly on population growth and changes in per capita real income. Since aggregate farm products have a relatively low price and income elasticity, increases in total utilization per person are expected to be small, regardless of possible higher incomes or lower prices.

Projected utilization of farm products by 1975 shows a level ranging from 40 to 45 per cent above 1953.[14] The projections reveal sizable increases in demand for livestock and products, poultry products, feed grains, fruits, vegetables, and tobacco. Limited increases will be needed for cotton and potatoes, while decreases in food grains, especially wheat and rice, will still enable requirements to be met. Although the sizable increases in food production that will be needed to meet future requirements of a rapidly increasing population will depend on a less than proportionate expansion in cropland, no food shortages are anticipated by 1975.[15]

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[14] Rex F. Daly, "The Long-Run Demand for Farm Products," Vol. III, No. 3, *Agricultural Economics Research* (July, 1956), pp. 73-91.

[15] U. S. Bureau of the Census, U. S. Department of Commerce, *Current Population Reports Population Estimates,* Series P-25, No. 123 (October 20, 1955), pp. 1-10.

Hugh H. Wooten and James R. Anderson, *Agricultural Land Resources in the United States—With Special Reference to Present and Potential Cropland and Pasture,* Agriculture Information Bulletin No. 140, U. S. Department of Agriculture (June, 1955), pp. i-ii—1-107.

Glen T. Barton and Robert O. Rogers, *Farm Output—Past Changes and Projected*

In 1954 rice, Irish potatoes, pasture, corn, cotton, tobacco, hay, nursery and flower crops, tomatoes, snap beans, sweet corn, and other vegetables accounted for approximately four-fifths of the humid area irrigated acreage. In view of the insignificance of irrigation a decade earlier these crops largely accounted for the increase in irrigated acreage in the humid area from 1944 to 1954.

It seems probable that large relative increases in acreages irrigated will take place for such high-value crops as tobacco, cotton, and certain vegetables; it appears also that corn along with hay and pasture would account for a large increase in irrigated acreage if expansion continues.[16]

Even if future expansion of humid-area irrigation results in large increases in irrigated acreages of feed grains and forage, after allowance is made for increases in acreages of other crops, particularly tobacco and cotton, the impacts from expanding irrigation would still not be great for livestock production. Increases in production of feed grains—assuming a doubling of 1954 humid-area yields on the additional irrigated land—would be relatively small. An additional corn acreage of 1.5 million, for example, yielding an increased 80 bushels per acre from irrigation combined with other practices would result in less than a 5 per cent increase in production of corn above the 1954 output. Although the assumed yield on the irrigated acreage is approximately 120 bushels per acre as compared with 42 bushels for the area in 1954, the small percentage of total corn acreage that would be irrigated lessens the significance of the increase in yield. Further, assuming that a half million acres resulting from the expansion of humid-area irrigated acreage is used to irrigate alfalfa hay, with an additional yield of 1 ton per acre, the increase in production of alfalfa above the 1954 output for the humid area would be only 2 per cent.

The livestock industry is more concentrated in certain of the Corn Belt and Lake States than in other regions. Where the future expansion in irrigated acreage of feed grains and forage occurs will probably be determined to a larger extent by the availability or lack of water than by other factors. Hence, indications point to an expansion of irrigated feed grains and forage in other regions as well as in the Corn Belt and Lake States.

Significance of Limited Water Supplies. A large share of the physical supply of water is limited for various uses because it is available as flood flow within a short period of time only. For the United States as a whole,

Needs, Agriculture Information Bulletin No. 162, U. S. Department of Agriculture (August, 1956), pp. 1-44.

R. G. Bressler, Jr., "Farm Technology and the Race with Population," Vol. XXXIX, No. 4, *Journal of Farm Economics* (November, 1957), pp. 849-864.

[16] Assumptions for acreage increases for these and small-acreage crops are based on long-run demand estimates for farm products.

it is estimated that nearly two-thirds of the run-off (the physical supply) is short-term flood flow. To date, it has been more economic to re-use available physical supplies of water than to impound additional supplies. For the humid area as a whole, for example, present withdrawal uses of water exceed the physical supply (the 1953-56 runoff) by 73 per cent. By regions, withdrawal uses of water in 1955 for all purposes including waterpower exceed the physical supply least (21 per cent) for the Corn Belt and most (129 per cent) for the Lake States.

Although irrigation presently accounts for a relatively small part of the total quantity of water withdrawn excluding that withdrawn for waterpower, and would represent less than 6 per cent of the total quantity presently withdrawn if it were increased to 5 million acres in the humid area, developments of this kind would necessitate significant adjustments in water supplies.

Increased supplies of water for irrigation would require reductions in withdrawal for other uses or increases in available supplies of water. The supply of irrigation water might be increased by decreasing the supply for other uses through recirculation and re-use of water for industrial purposes and by increasing industrial uses of saline water.[17] Nonirrigation uses are expected to increase considerably, however, with further industrial needs and population growth. Estimates for nonirrigation uses of water in the United States show that 283.4 billion gallons will be needed daily by 1975 as compared with 142.2 billion gallons used daily in 1955.[18]

If increases of saline water for industrial uses come about, larger quantities of water will be made available for other uses. Saline water for industrial purposes is currently used for the most part in the Northeast. Considering the higher economic return for water for uses other than for irrigation, prospects are not favorable for increased use for irrigation.[19] Rather the utilization of nonsaline water freed from the increased use of saline water appears likely to be limited to the increased needs for expanded industrial and public purposes. Although not yet certain, possibilities exist for increasing the supply of water from technical improvements in desalting sea water as well as more efficient use of present supplies of water. In addition, artificial rain-making may cause changes in local precipitation.

[17] See definition of saline water in Table.

[18] Walter L. Picton, *Water Use in the United States, 1900-1975*, BSB-136, Business and Defense Services Administration, U. S. Department of Commerce (January, 1956), p. 4.

[19] Some estimates show that the value added by manufacture for a given quantity of water used exceeds the value added by agriculture by a ratio of 140 to 1. See Sheppard T. Dowell, "Relative Economic Returns from Industrial and Agricultural Water Uses," *Journal American Water Works Association*, Vol. 48 (August, 1956), pp. 991-992.

Because of heavy precipitation and favorable geologic conditions, prospects are favorable for recharging ground sources in some parts of the humid area. Increasing ground-water supplies by artificial means would permit storage of flood flow underground with small losses from evaporation. But the tendency is to rely less on ground sources for irrigation water. In addition, in some coastal areas, falling water tables are bringing serious problems of salt water intrusion. Accordingly, the other alternative for increasing the supply of water for irrigation—increased storage of short-term runoff— would interfere least with other essential uses. Impoundments of this kind represent one of the better methods for increasing the supply of water, provided they can be developed economically. Unless these impoundments are accomplished by storage of surplus flood flow, sewage-treatment requirements would be seriously impeded by reduced flows brought about by increased use of natural stream flows for irrigation.

Research and Planning Needed for Increasing Water Supplies. Advanced planning for control of water use in the humid area is needed if the most efficient use of this increasingly scarce resource is to be attained. Planning and consequent legislation, interstate and regional in character, should contribute greatly to policy formulation and obviate if not lessen the necessity for piecemeal solutions such as those emanating from court actions to reconcile conflicts.

As a basis for more effective planning, information is needed on estimated future water needs for various uses, by watershed areas, as well as ways of economically increasing water supplies. Of particular significance is the need for information on use of water by local areas for irrigation, including rate and time of application, crops irrigated, and costs of using and increasing water supplies.

ANALYTICAL TECHNIQUES IN RELATION TO WATERSHED DEVELOPMENT*

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THIS paper concerns the role of objective estimation procedures in the evaluation of, and to some extent the planning of, small watershed development. Most objective estimates of results of watershed development are aimed at measurement of the economic benefits and costs of development. Under the Soil Conservation Service Program—which accounts for the bulk of watershed development—these estimates must be brought together to make an over-all comparison of benefit and cost that can be used in judging a proposed plan. Another way of stating what this paper is about is to say that it concerns the relation of benefit-cost analysis to small watershed development.

Possibilities for Refining Techniques

Some of the main characteristics of the present federal program are exemplified by proposed development of the Mud Creek, North Carolina, watershed.[1] As indicated in Table 1, the Mud Creek watershed bears out the fact that—in terms of public expenditure—the federal watershed development program is primarily a flood control program.[2]

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[1] The Mud Creek watershed provides an example of plans being prepared under the current federal program and is being used illustratively in this paper to show possible effects of some of the analytical procedures that will be discussed.

[2] See Morris L. Weinberger and Robert C. Otte, "Economic Evaluation of the Small Watershed Program," *Journal of Farm Economics*, Vol. 39, No. 5, December, 1957, p. 1263: "Review of the 150 watershed work plans prepared to date under Public Law 566 and the pilot program indicates that the majority of the projects are designed primarily to reduce agricultural flood damages and to restore former land productivity. Protection of residential, industrial, commercial, and transportation facilities is also an important function of many projects. In a few instances, it is the predominant purpose. In other watersheds, improved drainage alone or in combination with flood protection is the motive for works of improvement."

The effects of the largely privately-financed land treatment measures are not subjected by the Soil Conservation Service to objective estimation procedures for purposes of evaluating watershed development. The agency states, in *Watershed Protection Handbook*, Washington: Department of Agriculture, 1957, Section 6, p. 2: "The Department has found through experience that land-treatment measures installed with [Federal] assistance produce combined public and private benefits in excess of their costs. Since such other programs do not require a benefit-cost analysis for Federal assistance, it will not be necessary to determine the relation of benefits to cost for the land-treatment measures for watershed protection."

TABLE 1. APPROXIMATE COSTS OF IMPROVEMENTS PROPOSED FOR MUD CREEK WATERSHED, NORTH CAROLINA[a]

Type of Expenditure	Source of Funds	
	Public Law 566	Other
	(Dollars)	(Dollars)
LAND TREATMENT:		
Permanent Hay		253,000
Pasture Seeding		213,000
Farm Drainage		91,000
Farm Ponds		80,000
Roadside Erosion Control[b]	15,000	44,000
Cover Crops		25,000
Tree Planting		25,000
Sod Waterways		23,000
Strip Cropping		20,000
Terraces		9,000
Field Diversions		1,500
Critical Area Stabilization[b]	6,000	2,000
Technical Assistance[c]	128,000	11,000
Totals	149,000	797,500
STRUCTURAL:		
Floodwater Retarding Dams[d]	526,000	
Stream Channel Improvement	116,000	
Other Costs[e]		250,000
Totals	642,000	250,000
Grand Totals	791,000	1,047,500

[a] Adapted from figures in the work plan for this watershed. Figures do not include operation and maintenance cost, to be paid from nonfederal sources.
[b] For flood prevention.
[c] Includes $3,600 for flood prevention.
[d] Includes installation services of $158,800.
[e] Land, easements, rights-of-way and administration of contracts.

The present paper does not attempt to consider the benefits and costs of most of these largely privately-financed land treatment measures. However, land treatment measures that are primarily for flood prevention as opposed to conservation and improvement of lands on which they are installed are included in S.C.S. benefit-cost comparisons, and hence this type of land treatment does fall within the present analysis.

The S.C.S. considers land treatment aimed primarily at conservation of lands where they are installed to be one of the preconditions in flood prevention analysis. This is indicated by the statements that, "Flood prevention benefits will be calculated as the difference between damages with the land treatment measures for watershed protection installed and damages with all project measures installed." (*Ibid.*, Section 23, p. 8.) "The benefits of structural measures interdependent with land treatment measures for watershed protection are equal to the benefits of the interdependent measures minus the cost of the land treatment measures which is treated as an associated cost." (*Ibid.*, Section 6, p. 3.) The clear intent indicated by these statements would seem to be to get at benefits and costs of flood prevention assuming the land treatment for conservation is already installed, and the statements seem to indicate valid procedures for doing this.

Perhaps the most important thing to be said in placing the present discussion in perspective is that improved analytical techniques can make a contribution to watershed development, but they are not necessarily among the most pressing needs. The most pressing need in terms of making reliable evaluations may be to obtain better estimates of physical and economic conditions that will prevail in a watershed—particularly in the flood plains—after the development expenditures have been made. In many instances, reliance in making the prediction of future conditions is put on answers from farmers in surveys. Some scope for supplementing this information with wider use of programming and budgeting techniques seems possible.[3]

Another planning need that is often expressed is for consideration of a greater number of alternative development plans from which to choose.[4] Consideration of alternatives is sometimes made difficult by just the paper work necessary to test between alternatives.[5] It might be useful to try to formulate watershed planning problems mathematically in a way so that answers could be obtained from computing machines.[6]

While the techniques should be of help in meeting the above needs, they may be largely complementary—not substituting—with increased expenditures for watershed planning. A hypothesis is that we could go the most important part of the way if presently prevailing techniques were applied more intensively.

Let us turn to some recently advanced ideas for modifying government benefit-cost analysis and see how they might apply to watershed development.[7]

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[3] Experience with watershed development is accumulating, and systematic ex-post examinations of watershed projects—such as now underway in some cases—ought also to improve our ability to estimate effects. A recent report on ex-post evaluation of a watershed is Agricultural Research Service and Soil Conservation Service, *Watershed Program Evaluation, Six Mile Creek, Arkansas*, ARS 43-51, Washington: Department of Agriculture, 1957. Weinberger and Otte, *op. cit.*, describe the U.S.D.A. program of evaluation of installed projects.

[4] See Weinberger and Otte, *op. cit.;* Harry A. Steele, "Economics of Small Watershed Protection," *Agricultural Economics Research*, Vol. 8, No. 1, January, 1956, pp. 17-23; John F. Timmons, "Economic Framework for Watershed Development," *Journal of Farm Economics*, Vol. 36, No. 4, December, 1954, pp. 1170-1183. Moreover, one often finds persons close to particular watershed planning projects who communicate this view.

[5] There does not appear to be lack of knowledge of how to find and choose the most economic alternative given enough information. Marginal principles, together with examples applicable to watersheds, are presented in Soil Conservation Service, *Interim Economics Guide for Watershed Protection and Flood Prevention*, Washington: Department of Agriculture, 1956, Chapter 5 entitled "Application of Economic Analysis in Project Formulation."

[6] Koopmans has outlined an approach of this general type for water management involving hydroelectricity and water storage.

[7] A reason why improvement here does not seem to be among the most pressing

McKean has been concerned with the criterion or ranking problem.[8] He suggests that, in place of the usual benefit-cost ratio, "the ratio of net operating benefits (that is, benefits minus costs of operation) to investment cost, both converted to present values, be used."[9, 9a]

To illustrate the effect of this alternative method of comparison, the benefit-cost ratio of 2.6 for the proposed flood prevention developments of the Mud Creek watershed compares with a benefit-cost ratio of 1.8 for developments evaluated for the Savannah River watershed.[10] When the ratio suggested by McKean is applied to these same data the rank of the two projects is reversed. The result is 3.3 for Mud Creek and 15.2 for Savannah River.[11, 12]

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needs is that elaborate and commendably valid procedures for evaluating benefits and costs that arise in watershed development have been worked out in the Department of Agriculture. See the documents referred to in footnote 2.

[8] Roland N. McKean, *Cost Benefit Analysis and Efficiency in Government*, Research Memorandum 1445, Santa Monica: The Rand Corporation, 1955. A revised version is about to appear in book form. McKean makes many valuable suggestions in addition to the one being discussed here.

[9] McKean, *op. cit.*, p. 242.

[9a] After the present article had been accepted for publication, McKean's revised work appeared. His present position is that projects "might be ranked according to ratio of present worth to investment cost with the streams discounted at the marginal internal rate of return. Or, to use a simpler device, one that would point to the same set of investments, the projects could be ranked according to their internal rates of return." See Roland N. McKean, *Efficiency in Government Through Systems Analysis*, New York: John Wiley and Sons, Inc., 1958, p. 122.

Emphasis on the internal rate of return is a particularly important departure from his earlier formulation. I still prefer his earlier formulation, largely because it seems more consistent with the decision-making environment of government. Use of the internal rate of return is related to the assumption that a limited investment budget is to be allocated in order to attain maximum economic product. Thus McKean says, "If a single unique ranking could be devised, decision-makers could simply go down the list of projects as far as the budget would permit." *Ibid.*, p. 122. However, in actual decision-making in water resources development, these economic considerations provide only a part of a broader set of considerations taken into account in deciding to undertake a project. In this decision-making environment, the meaningfulness seems doubtful of a marginal internal rate of return for government that is different from the rate of return on investment in the economy at large. If this position is granted, it can be shown that ranking of projects by their internal rates of return discriminates against some types of economically desirable projects.

The foregoing ideas would have been elaborated more fully had the present article been written after instead of before McKean's book became available.

[10] The Savannah River watershed comprises parts of North Carolina, South Carolina and Georgia. See 83d Congress, 1st Session, *Survey Report of Savannah River Watershed*, House Document No. 40, Washington: Government Printing Office, 1953. The benefit-cost ratio of 1.8 reported in the text differs from the ratio of 1.3 presented in this document. I have calculated the ratio using the annual benefits and costs reported in the document in 1947 prices, whereas the document's 1.3 figure was based on projected 1955-65 prices and costs assuming intermediate employment levels. The change was necessary in order to be able to calculate the usual benefit-cost ratio and the McKean ratio from the same data.

[11] These comparisons are being used illustratively and do not necessarily imply any

The proposed Mud Creek project consists mainly of small dams, whereas the Savannah River watershed was planned under the older program and predominantly land measures were included, resulting in increased incomes from tree planting and conservation benefits. It is this difference in the nature of the programs that accounts for the reversal of rank as between the two methods of comparison. The Savannah River project is characterized by high annual operation and maintenance costs. These costs occur in the denominator of the usual benefit-cost ratio and make for a low ratio for Savannah River.[13]

Another advantage of the McKean ratio is that the ranking of projects is not haphazardly affected by the rate of discount. Figure 1 shows that the McKean ratio gives the same relative ranking for Savannah River and Mud Creek regardless of the rate of discount.[14] But the usual benefit-cost

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opinion as to the relative worth of these two projects, as no attempt has been made here to evaluate the benefit and cost data on which the comparisons are based. An impression is that analytical procedures used in watershed evaluation have been improving over the years and also that more care may now be used in making estimates of future conditions than was used previously. This would suggest that the data underlying the evaluations of these two projects may not be comparable, since study of the Mud Creek watershed was done more recently.

[12] Table 3 gives a comparison of the usual benefit-cost ratio and the McKean ratio for individual measures of the proposed Mud Creek Project. It indicates a similarity of ranking as between the ratios for measures of a given physical type. As pointed out in the next paragraph, the Mud Creek and Savannah projects are ranked so differently by the two ratios because the watershed measures being evaluated are so different.

[13] The difference between the usual benefit-cost ratio and the McKean ratio is that costs which will occur annually must be subtracted from both the numerator and the denominator of the usual benefit-cost ratio to arrive at the McKean ratio, so that McKean's ratio gives *net* annual benefits per dollar of installation cost. McKean has argued: "Should we think . .. of the allocation of a total-cost budget embracing operating expenses for future periods? No, the problem (for either a government agency or a businessman) is not really the allocation of such a budget—i.e. the present value of *all* expenses. The problem is the allocation of investment funds—that is, resources which must be brought to these ventures from 'outside' because the resources are not made available by incoming receipts from the ventures themselves." See McKean, *op. cit.*, p. 138.

While McKean's measure ought to aid in choosing among alternative projects, at present perhaps only limited attention is paid to the relative ranking of projects, so long as benefits exceed costs. That is, the economic analysis may act more as a constraint, in that it is a requirement of the federal program that a project have a ratio greater than one. Among the admissable projects, criteria other than the benefit-cost comparison often appear dominant. And it is true that McKean's measure gives the same answer as the usual benefit-cost ratio to the question whether benefits exceed costs. However, if the McKean measure were used, it might then be possible to argue more effectively for paying more attention to rankings.

[14] Since it is being assumed here that both projects have the same kind of time pattern of returns, the McKean ratio for both projects must be changed in the same proportion by a change in the discount rate. If the time stream of returns for both projects did not have identical shapes, then this result would not hold, and one would not want it to hold.

EFFECT OF RATE OF DISCOUNT ON BENEFIT-COST COMPARISONS

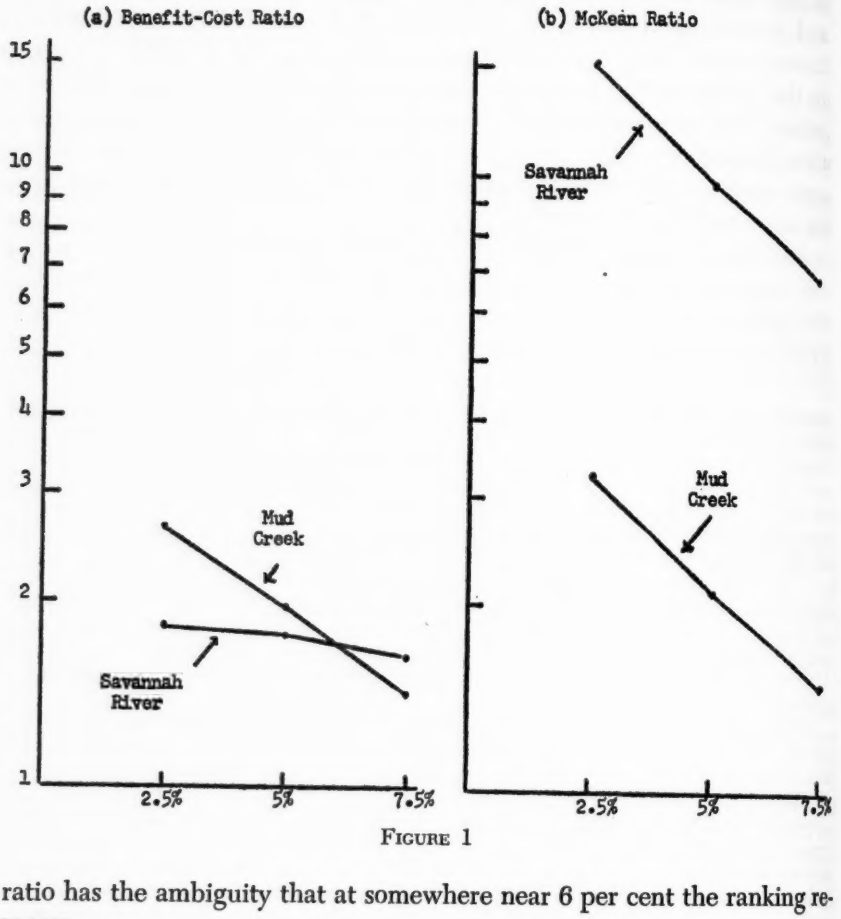

FIGURE 1

ratio has the ambiguity that at somewhere near 6 per cent the ranking reverses.

A recent suggestion by Renshaw is that benefit estimation be based on the estimated increase in land values that will result from watershed protection.[15] As a minimum, the land value approach might be used as a

[15] Edward F. Renshaw, *Towards Responsible Government, An Economic Appraisal of Federal Investment in Water Resource Programs,* Chicago: Idyia Press, 1957, p. 79, f. 19. The effect of present methods is that the expected increased income streams from watershed measures are estimated by analysts and then capitalized at an assumed rate of discount. The factor of production which is changed by watershed measures is land. The land market goes through the same kind of process, with resulting upward valuations of land to which increased returns accrue.

It might be argued that the land market approach would not take into account possible extra-market benefits of watershed development. However, the benefits currently evaluated, according to the documents referred to in footnote 2, consist of the kind that ought to be reflected in market values. Thus, the approach presently in use and the land value approach try to measure similar benefits.

supplement to present methods. In doing this, the rate of discount ought to be examined which would make the discounted sum of benefits equal to the expected increase in land values. Light would then be thrown on the reasons for possible discrepancies between the two approaches. If the rate of discount necessary to make estimated benefits equal to expected land value increase, approximated the land market discount rate, it would suggest that discrepancies were due to differences in discount rate being used. If the noted rate was out of line with the land market rate, it would suggest that discrepancies were due to differences in the estimated stream of benefits.

A problem that would need to be worked out if the land value approach were solely used arises from changes in the rate of discount in the land market. Table 2 is suggestive of broad swings that have gone on. One possible way to face this problem is to decide what a probable long-run normal market rate of discount is and adjust estimates to conform with this rate if they were made when the normal rate did not prevail.

Within the framework of present procedures, perhaps the main shortcoming at the analytical level is use of too low a discount rate—2.5 per cent. The effect that rate of discount can have on project planning shows up in Figure 1. Table 3 illustrates the effect on project planning. At higher rates of discount, a considerable number of installations would be eliminated because their benefits would fall below costs.[16]

The use of a lower rate of discount than is earned by real investment in the private sectors implies carrying government investment to a further margin than private investment and hence failing to attempt to maximize the return on investment as a whole.[17] An interest rate approach aimed at reflecting actual expected alternative return would lighten needs for allowance for risk in evaluating and planning projects. Since the discount rate would reflect actual expected alternatives, the main aim in estimating the benefits and costs to be discounted would be to make them as accurate as possible.[18] In addition, an innovation that may be worth trying would

[16] These figures may underestimate changes because, to the extent that the measures of the project are interrelated, the elimination of one may necessitate replanning several others.

[17] While the rate of return in the private sectors is probably extremely variable as between different types of real investment, a conjecture is that the average realized return is quite high. For example, the 1932-54 average rate of return on real assets for 41 food processing firms has been estimated as 13.78 per cent. (This measurement is explained in chapters 4 and 5 of my *Earnings of Labor and Capital in the Food Processing Industries*, Ph.D. thesis, University of Chicago, 1955.) It is possible that this is an overestimate of the type of return we are trying to get at in the above discussion, as the 13.78 per cent may reflect, partly, lucrative past investments, the opportunities for which may not exist in investments currently going on. On the other hand, the food processing sector is not particularly noted for being a sector where returns are high.

[18] The planning documents that have been referred to speak in general of allowing

TABLE 2. VALUE OF LAND AND BUILDINGS AND APPROXIMATED RENTAL VALUE
(Billions of Dollars)

Year	(1) Value of land and buildings[a]	(2) Approximated rental value[b]	(3) (2) as a per cent of (1)[c]	Year	(1) Value of land and buildings[a]	(2) Approximated rental value[b]	(3) (2) as a per cent of (1)[c]
1910	34.8	1.7	4.8	1934	31.9	1.5	4.8
1911	36.0	1.7	4.8	1935	32.9	1.9	5.6
1912	37.3	1.8	4.7	1936	33.9	2.0	5.9
1913	38.5	1.8	4.6	1937	34.8	1.9	5.5
1914	39.6	1.8	4.6	1938	34.7	1.7	4.9
1915	39.6	2.0	5.1	1939	33.9	1.8	5.5
1916	42.3	2.6	6.0	1940	33.6	1.9	5.7
1917	45.5	3.7	8.2	1941	34.4	2.7	7.8
1918	50.0	3.9	7.8	1942	37.5	3.9	10.3
1919	54.5	4.1	7.6	1943	41.6	4.6	11.0
1920	66.3	2.6	3.9	1944	48.2	4.9	10.2
1921	61.5	1.9	3.1	1945	53.9	5.0	9.2
1922	54.0	2.2	4.1	1946	61.0	5.3	8.6
1923	52.7	2.5	4.8	1947	68.5	6.2	9.1
1924	50.6	2.8	5.6	1948	73.7	6.7	9.1
1925	49.6	2.6	5.3	1949	76.6	5.1	6.7
1926	49.0	2.4	5.0	1950	75.3	5.4	7.1
1927	47.6	2.8	5.8	1951	86.8	6.2	7.1
1928	47.5	2.7	5.6	1952	96.0	5.9	6.2
1929	47.9	2.6	5.4	1953	96.6	5.3	5.5
1930	47.9	2.0	4.2	1954	94.7	5.1	5.4
1931	44.0	1.2	2.8	1955	98.8	4.8	4.9
1932	37.2	.9	2.3	1956	102.7	4.8	4.7
1933	30.7	1.2	3.9	1957	109.5	4.9	4.5

[a] Agricultural Marketing Service and Agricultural Research Service, *Agricultural Outlook Charts 1958*, Washington: Government Printing Office, 1957, p. 75.

[b] For 1910–1947, D. Gale Johnson, "Allocation of Agricultural Income," *Journal of Farm Economics*, Vol. 30, No. 4 November, 1948, p. 746. Johnson uses the proportion of all land rented to blow up net rental to landlords. For 1948–1957, the figures shown above are 30 per cent of agricultural income—a relation that appeared historically fairly stable during 1910–47. Defense for this latter estimate is that most land is rented under share agreements that are probably sticky.

[c] This is rough as an estimate of the rate of capitalization in the land market, but this series and the rate of capitalization could be expected to have similar movements through time.

For an alternative estimate of the rate of return on farm real estate, see Agricultural Research Service, *The Farm Real Estate Situation*, ARS 43-74, Washington: Department of Agriculture, May 1958, p. 25. This estimate shows the same general swings but is more variable and tends to be lower. It calculates the return to land as a residual, the main part of the method being to subtract allowance for farm labor from net agricultural income.

be to calculate mathematical expectation based on probabilities of alternative outcomes. Three estimates of benefits might be made: modal or most likely benefits, low benefits and high benefits. Subjective probabilities would be attached to each set of estimates, and mathematically expected benefits could be calculated. The interest rate approach being suggested

for risk in view of the fact that the recommended 2.5 per cent rate is so riskless, but whether such allowances find their way into estimates to any significant extent is not clear.

TABLE 3. ALTERNATIVE BENEFIT-COST COMPARISONS FOR THE MUD CREEK WATERSHED[a]

	Discounting at 2.5 per cent		Discounting at 5 per cent		Discounting at 7.5 per cent	
	Benefit-Cost Ratio	Mc-Kean Ratio	Benefit-Cost Ratio	Mc-Kean Ratio	Benefit-Cost Ratio	Mc-Kean Ratio
FLOODWATER RETARDING STRUCTURES:						
No. 5	1.2	1.2	.82	.80	.60	.57
No. 9	3.6	5.1	2.7	3.3	2.1	2.3
No. 13	4.4	5.3	3.1	3.4	2.3	2.4
No. 22	2.6	3.2	1.9	2.1	1.4	1.5
No. 26	1.2	1.3	.83	.82	.61	.58
No. 28	1.3	1.4	.92	.91	.69	.64
No. 29	2.3	3.3	1.8	2.1	1.4	1.5
Nos. 33 and 41	2.7	3.5	1.9	2.2	1.5	1.6
No. 33a	1.5	1.8	1.1	1.2	.87	.83
No. 39a	2.1	2.4	1.5	1.6	1.1	1.1
No. 45	3.8	4.4	2.6	2.9	1.9	2.0
No. 47	2.8	3.4	2.0	2.2	1.5	1.5
No. 50b	4.3	5.9	3.2	3.8	2.4	2.7
No. 51	1.4	1.5	.95	.94	.69	.67
No. 52	2.4	2.6	1.6	1.7	1.2	1.2
No. 54	2.5	2.9	1.8	1.9	1.3	1.3
STREAM CHANNEL IMPROVEMENT:						
Mud Creek	2.1	3.2	1.7	2.1	1.3	1.5
Clear Creek	5.2	10.7	4.2	6.9	3.4	4.9
Bat Fork	1.5	2.2	1.2	1.4	3.6	1.0
Henderson Creek	1.2	1.5	.97	.95	.80	.67
LAND TREATMENT FOR FLOOD PREVENTION:						
Critical Area	5.7	9.7	4.4	6.3	3.5	4.4
Roadside Erosion	2.0	2.3	1.4	1.5	1.0	1.0
THE TOTAL PROJECT	2.6	3.3	1.9	2.1	1.4	1.5

[a] See the text of this paper on how the calculations are done. Original data are from the work plan for the Mud Creek watershed. Some of the benefit estimates have been revised.

here aims at reducing subjectivity in project evaluation and at making explicit the subjectivity that remains.[19]

Consider a final possible analytical refinement to be discussed. A famous type of conflict of interests among people occurs between users of flood plain land that will be protected and users of land that will be flooded out to achieve the protection.[20] Suppose a choice is being made

[19] Using slightly different reasoning, Krutilla and Eckstein recently further corroborated the idea that the 2.5 per cent rate now in use is too low. See John V. Krutilla and Otto Eckstein, *Multiple Purpose River Development*, Baltimore: The Johns Hopkins Press, 1958, Chapter IV.

[20] Within a small watershed, where the protected land and the flooded land are close together and where whole farms are not likely to be flooded, the flooded land may be able to be purchased rather easily—so that it appears rather easy for the "losers" to be compensated. More knotty problems occur when a proposed alternative water resources investment—such as a dam further down—would flood out all or part of the small watershed in question. This example is pertinent to the Mud Creek watershed. Two different plans have been prepared for the French Broad River, to which

between developing a small watershed and building a dam on a river further down that will protect a city and flood out all or part of the watershed. The people of the city want the dam, whereas the people of the watershed do not want the dam and would like to undertake watershed investments.

A first reaction may be to undertake that investment which shows the greater net economic benefits on the basis of the benefit-cost analysis. To see why this may not unambiguously be the best choice, suppose that the dam protecting the city shows greater net economic benefits than the watershed investments but that—as is likely to be the case—in the benefit-cost analysis, the estimated cost of the land inundated aims at its market value. The market value of the inundated land may not reflect all of the loss involved in inundating it, because the people who live or work on the land may be getting a surplus that will not be replaced when they move someplace else. Because of way of life, friends and so forth, and perhaps because of comparative entrepreneurial advantage connected with familiarity with this land, the land may be worth more to the people using it than it is to anybody else. Hence the market value of the land may not reflect its entire worth to the people using it.[21]

This suggests that, for lands that will be flooded out, legal powers of condemnation not be used and that the cost of the land be valued at what it would take to make the people want to give up the land. If the project will not show a favorable benefit-cost ratio when these valuations are used, then the gains from the proposed project would not appear to be great enough to compensate the losers. In other words, the project would not then appear to be truly economic. If the project still appeared economic when the true worth of the prospectively flooded land to the people using it was considered, then, in carrying out the project, the criterion for payments over and above market value of the land might be use—not ownership—of the land to be flooded. The surplus that has been referred to seems more likely to be associated with use than ownership of the land.

An argument against the procedure that has been discussed in connection with this example might be that it would make the possibility for users of prospectively flooded land to ask exhorbitant prices to relinquish it—that their asking prices would be influenced by the amount of money

Mud Creek is tributary. Both of these plans call for dams that would flood a good portion of the land which the watershed development proposes to protect. Opposition to the French Broad River plans by the people of Mud Creek watershed is described as very high.

[21] This surplus phenomenon arises with land because land is so unique. Most other things that are bought and sold are probably homogeneous enough so that any surplus enjoyed from a unit of the thing can readily be replaced by purchase of an alternative unit of it at a like price.

they thought they could extract. At the extreme, a counterargument could be that this is no particular objection. We would at least be in the "contract" range, where there is definitely net gain from the event, and the bilateral monopoly type of problem of determining the exact price would have mostly to do with the distribution of the gain. Does not equity suggest that we lean in the direction of ensuring that flooded out people do not lose, even if it may mean that they might sometimes gain quite a bit?[22,23]

No pretense is made here to have ironed out or anticipated the problems that would be found in attempting to carry out the procedure. The contention is, however, that this procedure may suggest a possibly promising direction to go in resolving conflicts of interest, aiming at the choice of projects so as to maximize economic benefit.[24]

Possibilities for Wider Application of Techniques

Until we have studies aimed at finding the unrestrained maximum net benefit in a watershed development, we cannot sense the extent to which tying the federal program to a system of soil conservation leads to missing alternatives that would be superior;[25] for many will feel suspicion toward

[22] However, the procedure is not motivated primarily by equity considerations. Rather it is motivated primarily by the thought that letting people bargain is one way to ensure that the losses in surplus are adequately taken into account.

The often strong objections of people who are flooded out is evidence that present compensation procedures sometimes leave them worse off. On the other hand, a common reaction among those with whom I have discussed the procedure being suggested is that residents of flooded land should not be in a position to extract all of the gains of a project for themselves. Ideas of justice might require that some maximums in compensation still be imposed. At the least, the analysis in this paper seems to indicate that the maximums should be higher than they now are.

[23] On possible conflicts of interest *within* a watershed, the requirements in the federal program that local people want the development and that the measures be planned that they desire may tend to be in accord with conclusions suggested by this example.

[24] A conversation with Harry A. Steele led to the line of thought followed in the conflict-of-interest example that has been discussed.

[25] Section 4 of Public Law 566 (as amended by Public Law 1018, August 7, 1956) requires that "local organizations shall . . . obtain agreements to carry out recommended soil conservation measures and proper farm plans from owners of not less than 50 per centum of the lands situated in the drainage area above each retention reservoir to be installed with Federal assistance." In speaking of proper farm plans, the *Watershed Protection Handbook,* Section 2, p. 3, alludes to land treatment "to prevent further deterioration of soil and water resources [to be applied] to all land in the farm or ranch unit." It was pointed out in footnote 2 that the land treatment costs for the most part cannot be paid from 566 funds and that no benefit-cost analysis is carried out for them—as the S.C.S. assumes the benefits from the land treatment exceed the costs.

These and other provisions—such as the exclusion of dams that can impound more than 25,000 acre-feet of water and the requirement that plans must be made for a land area not over 250,000 acres—limit the alternatives that can be considered in watershed plans.

the notion that the optimal land treatment measures are the *a priori* ones required by the present program.[26, 27]

Moreover, if upstream installers of land treatment measures are required to bear land treatment costs even though it is claimed that these make significant downstream sediment-reduction contributions to the flood control program of the watershed, ideas of cost allocation[28] are violated in a way that may make for incentives against local participation in watershed development. Projects could be precluded by the cost-sharing arrangements even though an over-all plan exists where the excess of benefits over costs is high. Here are three phenomena that could contribute to the difficulties that have sometimes been experienced in securing needed local participation in watershed projects: (a) lack of private benefits over costs—which could be due, for example, to overestimation of benefits by agency analysts or to exclusion of required measures from the benefit-cost analysis which are really uneconomic; (b) cost-sharing arrangements; (c) legal barriers to participation. Legal barriers have received attention.[29] It is not being suggested that (a) and (b) are definitely important; rather, it is being suggested that they may merit investigation. The possibility exists that they could lead to lack of want of watershed development by local people sufficient to overcome the desire for federal contributions for flood control.

Is there an optimal set of arrangements for carrying on watershed development?[30]

[26] These measures reduce sedimentation of flood control installations, but the question is whether the measures are planned optimally with a view to this contribution.

[27] The paper by A. J. Coutu, "Consistency and/or Inconsistency of Income and Conservation Objectives in Watershed Development" presented at the TVA Seminars for Cooperators in Agricultural Economics Research Activities, Knoxville, March 26, 1958, outlines research aimed at finding a more nearly unrestrained maximum, in considering both income and conservation objectives as well as approaches to conservation besides land treatment.

[28] Two problems are, first, that a part of the cost allocation is imposed *a priori* without using such principles of cost allocation as have been developed, and second, it can be argued that payments should be based on benefits received regardless of cost allocation. The latter issue has been investigated by S. V. Ciriacy-Wantrup, "Economic Analysis of Water Resources Policies," *Water Resources and Economic Development of the West,* Research Needs and Problems, Report No. 1, Berkeley: Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, 1953, pp. 21-40. The federal watershed cost-sharing procedures are beset by both the problems just noted.

[29] Robert C. Otte, *Local Resource Protection and Development Districts, Statutory Functions and Powers as Related to the Watershed Protection and Flood Protection Act,* Washington: Department of Agriculture [Agricultural Research Service], 1957; Stanley W. Voelker and John Muehlbeier, "Institutional Arrangements for Watershed Programs," *Journal of Farm Economics,* Vol. 36, No. 5, December, 1954, pp. 1184-1196.

[30] Pertinent literature, aimed mainly at the West but ranging more fully than will be done here into the real problems encountered in the operation of institutions, is

A frank statement about federal contributions to flood control might be that they constitute subsidy payments to flood plain land owners. If it is thought that these are not desirable or that important ends which they may be aimed at—such as regional redistribution of wealth or regional development—can be furthered more efficiently by alternate means, a conclusion would have to be that the optimal set of arrangements would not include extensive federal contributions to flood control.

Yet, even if the view about subsidy in flood control is accepted, there is the fact that watershed situations afford classic examples of so-called neighborhood effects. What one individual does or does not do imposes benefits or costs on other people, and he may not have market incentives to take these imposed effects into account.

The existence of these situations suggests a desirable and active role for government in watershed development. There may be verifiable gains from identifying possible downstream benefits from upstream measures, planning projects to see if possible benefits exceed costs, and helping the beneficiaries work out agreements to pay those on whose lands the measures would be carried out. Because the benefits and costs may not be readily clear unless technical planning is done and because ordinary legal and other arrangements may not be conducive to the working out of these economically beneficial agreements, a market economy unaided may overlook this type of possibility for economic gain.

A kind of government program then suggested would be one of technical and legal assistance in watershed development but without funds for direct expenditure on particular investments. The justification for eliminating direct government expenditure is that it seems arbitrary to give subsidies to people who happen to own flood plain land. In addition to the technical and legal assistance aimed at finding profitable investments missed by the market economy, credit assistance could be provided. Many of the investments would have long amortization periods, and farmers might find it difficult to secure loans for this type of investment within the framework of existing financial arrangements. Consideration might be given to the insurance and underwriting of credit—patterned, say, after F.H.A.[31]

Water Resources and Economic Development of the West, Institutions and Policies, Report No. 2, Bozeman: Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, 1954, and S. V. Ciriacy-Wantrup, *Resource Conservation, Economics and Policies*, Berkeley: University of California Press, 1952.

[31] A beginning toward the objectives suggested in this paragraph is made in the present federal watershed law. Sections 3 and 5 of Public Law 566 (as amended by Public Law 1018, August 7, 1956) contain several provisions for technical and legal assistance. Section 8 authorizes the Secretary of Agriculture to make loans for financing the local share of costs.

A METHOD FOR DEALING WITH TIME IN DETERMINING OPTIMUM FACTOR INPUTS

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DESPITE extended efforts devoted to the economic analysis of agricultural experiments, many methodological problems remain to be solved.[1] One limitation of the application of traditional production theory to many problems involving optimum factor combinations arises from the static (timeless) framework of the theory. Ordinary static procedures for finding optimum factor combinations are appropriate where there is no essential difference in the time required to assimilate or "feed in" varying quantities of factors. As an illustration, static procedures are appropriate for specifying optimum fertilizer nutrient inputs since fertilizer can be applied in practically any desired amount. But for production situations where time is required for additional inputs of factors, time does need to be integrated into the analysis.

Selection of optimum feed inputs for farm animals falls into the class of production situations requiring a more dynamic approach. Restrictions imposed by the animal stomach may cause the ordinary "least-cost" ration to be nonoptimum when the cost of time is considered. For example, a more costly ration may be preferred to the so-called least-cost ration if it permits the desired marketing weight to be attained sooner.

Research workers have been aware of the problem of changing time requirements for different rations. In some studies, time has been predicted as a function of the consumption of specified feeds.[2] It was thereby not only possible to predict the length of time required for the animal to consume a given ration, but also to compute least-time rations. Although this method quantified some elements of the problem, it did not integrate time and static marginal productivity. Least-time, least-cost, or some intermediate combination of ration could be selected, but such a choice would be arbitrary.

Correct answers to inappropriate questions can result in failure of method. Basic procedures in production economics were designed to provide correct answers to two related questions: (a) What is the cheapest combination of factor inputs for obtaining a given output, and (b) what is the optimum level of output?

[1] Earl O. Heady, David D. Mason, Earl R. Swanson, and Glenn L. Johnson, "Economic Implications of Agricultural Experiments," *Journal of Farm Economics*, 39:360-397, May, 1957.

[2] For one of the first uses of this method, *cf.* Earl O. Heady, Roger Woodworth, D. N. Catron, and G. C. Ashton, "New Procedures in Estimating Feed Substitution Rates and in Determining Economic Optima in Pork Production," Iowa Agricultural Experiment Station Bulletin 409, Ames, Iowa, 1954.

Questions (a) and (b) are answered by determining how far to go on the isocline, according to relative factor and product prices. But rather than answering questions (a) and (b) which ignore time, answers should be sought for two different questions:

(c) Given a limited, fixed time for the production process in a subperiod of production, what would be the most profitable combination of factors to use?

(d) What is the optimum length of time for the subperiods of production, considering the longer over-all production period?

Question (d) can be handled by first calculating the answer to (c) for various subperiods and choosing the most profitable in relation to the longer over-all period. For convenience in finding answers to (c), the relative time per unit required by individual factors for conversion into product should be "properly" expressed (depending upon the algebraic form of the production function). The optimum factor inputs can be computed for a given time period by combining the factor time requirements with the production function. This method is easily applied when the production function is of the ordinary quadratic form.[3] For example, assume the following where Y is output or product and X_1 and X_2 are factor inputs:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_1^2 + b_4X_2^2 + b_5X_1X_2. \tag{1}$$

The rate of input for one factor should be expressed functionally in terms of the input of the other factor and time, as the following:[4]

$$X_1 = c_1T + c_2T^2 + c_3X_2. \tag{2}$$

For a given time period, T_o, the input of factor X_1 is a function of X_2 only.

$$X_1 = k_0 + c_3X_2. \tag{3}$$

If one imposes (3) as a condition for the production function (1), (4) is obtained.

$$Y = k_1 + k_2X_2 + k_3X_2^2. \tag{4}$$

The altered production function (4) predicts what happens to output for the fixed length of production period as factor X_2 replaces factor X_1 in the production process. (The quantity k_1 represents the production that is possible if only X_1 were used.)

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[3] The method also works conveniently for the square-root quadratic production function.

[4] For ease in solving, factor inputs need to be expressed in the lowest power of the quadratic function. For example, for the square-root quadratic, the square root of one factor should be expressed as a function of time and the square roots of the other factors.

To utilize (4), one must also express the total cost function in terms of the fixed production period. Ordinarily, total cost would be

$$\text{T.C.} = P_{x_1}X_1 + P_{x_2}X_2. \tag{5}$$

If economists consider the fixed time period (3), they may also express total cost in terms of X_2 (as for the production function).

$$\text{T.C.} = P_{x_1}k_0 + P_{x_1}c_3X_2 + P_{x_2}X_2. \tag{6}$$

Optimum input of X_2 is then readily determined by equating the derivative of (4) multiplied by the product price with the derivative of (6).[5] The optimum amount of X_1 is then specified by (3).

It is of some theoretical interest that in this method the optimum factor combination is directly affected by the product price. In traditional procedures of production economics, the optimum combination of factors to achieve a given production is not affected since the equation of the isocline is independent of the product price.

By computing the profit positions possible within a longer over-all planning period for a number of assumptions regarding the length of the shorter sub-periods of production, one can determine the optimum length of time for the individual production process as accurately as needed. An empirical example of the proposed preceding method is presented in the following.

On the basis of experiments conducted by Arscott, *et al.*,[6] an economic evaluation of the relative feeding values of corn, barley, and fat was recently completed.[7]

To reflect these experimental findings, the production function was approximated by the following regression equation:

$$\begin{aligned} Y = {} & 0.08 + 0.498C_m + 0.437B_m + 0.687F_m - 0.0174C_m^2 \\ & - 0.0164B_m^2 - 0.135F_m^2 - 0.0288C_mB_m - 0.0213C_mF_m \\ & - 0.00266B_mF_m + 0.0111P_cC_m + 0.0271P_bB_m. \end{aligned} \tag{7}$$

In the above equation, Y refers to predicted broiler weight in pounds; C_m, the pounds of "corn mash" consumed (corn, plus its proportionate share of protein, vitamin, and mineral supplement); B_m, pounds of

[5] Diminishing returns are presumed for the production surface as determined by the coefficients of (1).

[6] G. H. Arscott, W. H. McCluskey, and J. E. Parker, 1957. "The Use of Barley in High-Efficiency Broiler Ration. 2. Effect of Stabilized Animal Fat and Pelleting on Efficiency of Feed Utilization and Water Consumption," *Poultry Science* 37 (1): January, 1958, pp. 117-123.

[7] A nontechnical report has been prepared by W. G. Brown and G. H. Arscott, "An Economic Analysis of the Substitution Value of Barley and Fat for Corn in Broiler Rations," Oregon Experiment Station Circular of Information 585, Corvallis, Oregon, 1957.

"barley mash" consumed; F_m, pounds of "fat mash" consumed; C_mB_m, C_mF_m, and B_mF_m are the respective interaction terms; and P_cC_m and P_cB_m represent the added feeding value obtained from pelleting the ration.

Logically, equation (7) is well suited to reflect the physical response of the broilers to the different rations. The pelleting terms, P_bB and P_cC, allow the productivity of barley to increase more relative to corn for pelleted rations. Approximately 99.5 per cent of the total variation was accounted for by equation (7).

Rate of factor input—in this case, the rate of feed consumption per bird—was estimated from the same experimental data as follows:

$$(8) \quad (C_m + B_m + F_m) = -0.03 + 0.152T + 0.082T^2 + 0.045B_m.$$

In equation (8), T and T^2 refer to time in weeks. The term T^2 was included because total feed consumption increased at an increasing rate during the experiment. All three regression coefficients were highly significant, accounting for almost 99 per cent of the total variation in feed consumption. Rewriting (8) in terms of corn-mash consumption.

$$(9) \quad C_m = -0.03 + 0.152T + 0.082T^2 - 0.955B_m - 1.0F_m.$$

If one considers the preceding time relationships and the broiler-feed function (7), what is the economic optimum feed combination for a fixed feeding period of, say, 9 weeks? For simplicity, consider first the case involving only corn and barley mash in (7) and (9) by setting $F_m = 0$. Then, substitute $C_m = 7.98 - 0.955B_m$ into (7), and obtain (10).

$$(10) \quad Y = 2.95 - 0.0032B_m - 0.0048B_m^2.$$

The altered production function (10) is of a form such that it predicts what happens to the average weight per broiler at 9 weeks as barley replaces corn in the ration. A person can see by examining (10) that if barley mash were as costly as corn mash, no barley should be fed since the 9-week broiler weight would be decreased. However, with cheaper barley, there is a possibility of saving money by substituting barley for corn.

To utilize (10), one must express the cost of substituting a pound of barley mash into the 9-week ration in terms of corn mash, since the feeding of one pound of barley reduces the consumption of corn by 0.9555 pound according to (9). If barley mash costs \$0.0420 per pound and corn mash \$0.0502, the relevant marginal cost of adding barley mash to the ration for the 9-week period would be $\$0.0420 - 0.955 \times (\$0.0502)$ or $-\$0.005941$ per pound.

An assumed broiler price of \$0.16 per pound indicates an optimum input of 3.53 pounds of barley mash. Substituting this quantity of barley into (9), where T = 9 weeks, one arrives at 4.61 pounds for corn mash. These in-

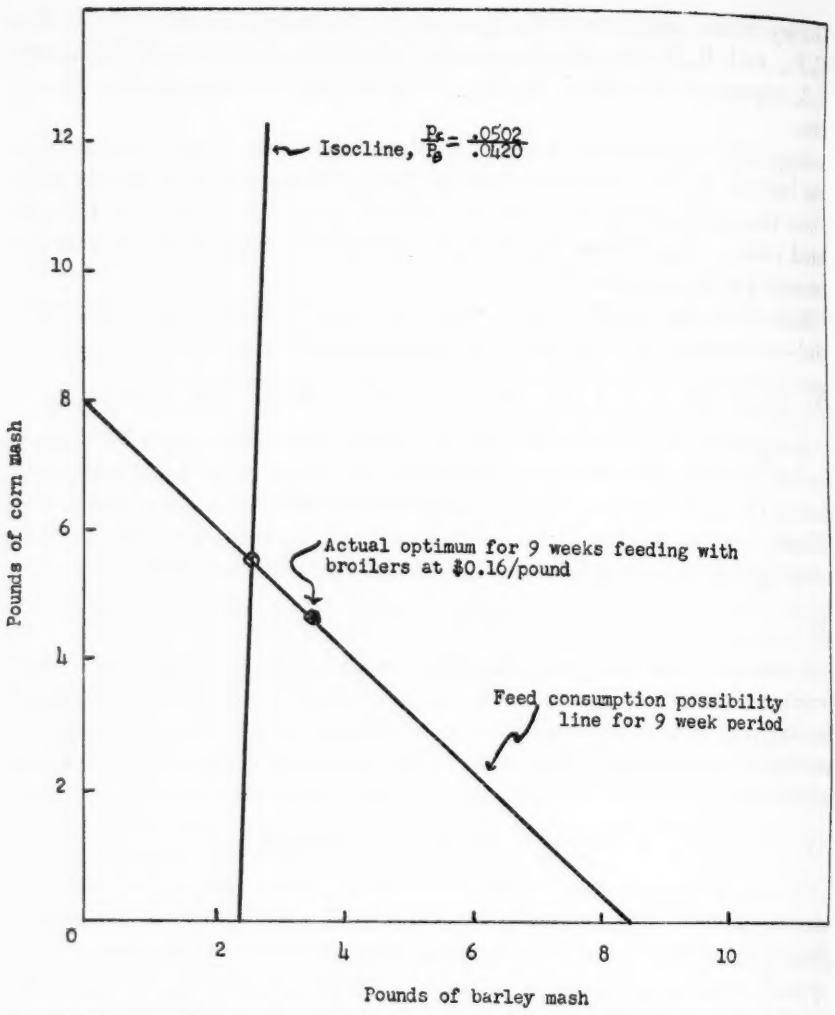

FIG. 1. DIVERGENCE OF AN OPTIMUM FEED COMBINATION FOR A FIXED TIME PERIOD FROM THE ISOCLINE (LEAST-COST RATION).

puts maximize expected profits under the preceding prices for the 9-week feeding period.

These inputs can be compared with the ordinary least-cost ration (staying within the stomach restriction, $C_m = 7.98 - 0.955B_m$) of 5.56 pounds of corn mash and 2.54 pounds of barley mash. Graphically, this solution is shown in Figure 1 by the intersection of the isocline with the stomach restriction line for the 9-week period.

Increased profit for the actual optimum over the pseudo least-cost op-

timum is small under the prices used here. However, the effect on margin-over-feed cost could be substantial under some price and feeding conditions. Divergence of the actual optimum combination of feeds from the least-cost ration under given factor prices depends chiefly upon the product price and length of feeding period, as well as the physical relationships involved.

Essentially the same procedure is followed in determining the optimum combination of three ingredients (corn, barley, and fat) for a specified feeding period.[8] For a 9-week feeding period and with corn mash, $0.0502; barley mash, $0.042; fat mash, $0.07605, and broilers, $0.16 per pound, the following inputs are indicated for the least-cost ration as compared to the actual 9-week optimum:

	Least-Cost Ration (Considering stomach restriction)	Actual Optimum for 9-Week Feeding Period
	(pounds)	(pounds)
Corn mash	3.26	2.84
Barley mash	4.05	4.60
Fat mash	0.85	0.75

According to these figures, less corn, more barley, and slightly less fat should be added to the ration than for the ordinary least-cost ration. The rationale for more barley is that with a low broiler price of $0.16 per pound it would not pay to feed as much of the more expensive corn and fat when the birds are to be held 9 weeks. If a broiler price of $0.25 were assumed for the 9-week feeding period, then the more expensive and productive energy sources are favored:

	Least-Cost Ration (Considering stomach restriction)	Actual Optimum for 9-Week Feeding Period
	(pounds)	(pounds)
Corn mash	3.26	3.80
Barley mash	4.05	3.42
Fat mash	0.85	0.91

If one uses the same method to find the optimum ration for various fixed subperiods of production, the optimum length of feeding period is decided by comparing costs and returns for the over-all planning period resulting from various lengths of the subperiods.[9] For broilers in Figure 2, optimum rations have been computed for 7-, 8-, 9-, and 10-week feeding periods for broiler prices of $0.16, $0.20, and $0.25 per pound. (For

[8] One feed variable is eliminated from (7) by substituting the variable in terms of the other two from (9). Then, the optimum quantities of the two variables are computed and the value for the third variable calculated from (9).

[9] For some production problems, the time period is fairly well specified; for example, some poultrymen replace their laying flocks each fall with pullets. In such a case the problem would be to maximize profits from the flock for the 12 months. Similarly, the length of lactation for dairy cows may be specified.

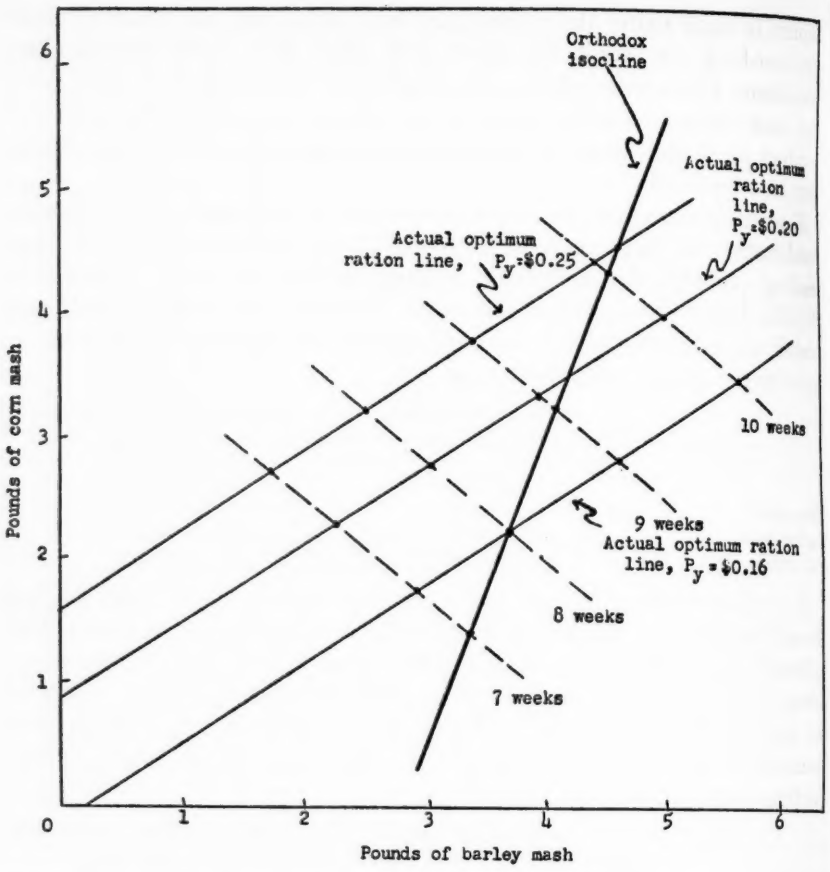

FIG. 2. OPTIMUM CORN AND BARLEY MASH COMBINATIONS FOR FOUR TIME PERIODS AND THREE PRODUCT PRICES COMPARED TO THE ORTHODOX LEAST-COST RATION (ISOCLINE). CORN, BARLEY, AND FAT MASH IS ASSUMED TO BE $0.0502, $0.0420, AND $0.07605 PER POUND, RESPECTIVELY.

simplicity, only the barley and corn quantities are presented graphically, although optimum fat inputs were also computed.)

For a broiler price of $0.20 per pound, the orthodox least-cost ration line underestimates the optimum amount of corn relative to barley for the 7-, 8-, and 9-week feeding periods. For feeding 10 weeks, too much corn would be predicted.

Optimum feed inputs for broilers at $0.25 per pound are presented in Table 1. Under this relatively high price of $0.25, larger amounts of the more productive but expensive corn and fat inputs are specified than would be expected from the orthodox isoclines, especially for the shorter time periods. This increase in corn and fat is logical because the increase

TABLE 1. OPTIMUM INPUTS, CONSIDERING TIME, OF CORN, BARLEY AND FAT MASH FOR FOUR LENGTHS OF FEEDING PERIOD FOR A BROILER PRICE OF $0.25 PER POUND

	Feeding Period in Weeks			
	7	8	9	10
Pounds of corn mash	2.72	3.22	3.80	4.43
Pounds of barley mash	1.73	2.53	3.42	4.41
Pounds of fat mash	0.67	0.79	0.91	1.05
Predicted pounds of broiler	2.24	2.67	3.08	3.45
Value @ $0.25 per pound	$0.559	$0.667	$0.770	$0.863
Margin over feed and chick cost[a]	0.099	0.139	0.167	0.175
Batches per year[b]	5.33	4.80	4.36	4
Total possible margin for plant with 10,000 bird capacity[c]	$5275	$6677	$7270	$7016

[a] Assumed prices for corn, barley, and fat mash was $0.0502, $0.0420, and $0.07605 per pound respectively. Chicks were $20 per hundred.

[b] It was assumed that 48 weeks were available for feeding with two weeks between batches for cleaning and restocking.

[c] Cost includes only feed and chick cost and does not include charges for labor, interest on investment, etc.

in value of product more than offsets the saving in feed cost for the limited feeding periods.

Although the greatest margin over feed and chick cost in Table 1 results from feeding the birds 10 weeks, greater yearly returns would be forthcoming from feeding 9 weeks and handling more birds. Even though still more birds could be handled by feeding 8 weeks, total annual returns were reduced because of the greater drop in margin over feed and chick cost.

If the orthodox least-cost ration recommendation is followed, the 9-week feeding period would again be the best period of the four considered. For 9-weeks, 3.26 pounds of corn mash, 4.05 pounds of barley mash, and 0.85 pounds of fat mash would constitute the ordinary least-cost recommendation. From these inputs, a broiler weight of 3.06 pounds would be predicted. Since the preceding feed inputs differ only slightly from the actual optimum inputs (see Figure 2), only a small reduction in profit results from using the traditional least-cost recommendation. Loss in profit from ignoring time would be greater where there was more divergence in the specified inputs.

Conclusions

Although the pure theory of production economics may be inadequate in its simplest, most abstract form for many complex situations, there is often opportunity to use statistical and mathematical techniques and adaptations to improve results. It is believed that the preceding research illustrates some of the possibilities of improved methodological procedures.

SOME PROBLEMS OF LINEAR DISCRIMINATION*

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TO CLASSIFY items into like groups is a methodological problem in virtually any research effort. The purpose of classification is specified by the problem of the research. The methodological objective is to develop classification criteria with which to identify a newly observed item as a member of a group reasonably homogeneous in terms relevant to the research problem. Thus it is required that the grouping be done on the basis of measurable characteristics and that the groups be defined in terms that permit the investigator to evaluate the reliability of his (new) identification.

The simplest classification problem is one in which groups can be distinguished according to one variable reflecting a characteristic in the items to be classified. Thus it might be proposed to classify a phenomenon A into classes A_1 and A_2 according to values taken by X, which measures a characteristic of A. Specifically, A_1 and A_2 will be said to constitute separable groups if the mean of X in A_1 differs significantly from the mean of X in A_2. The significance of the difference is affected by an estimate of standard error of the difference between means and the probability criterion according to which it is agreed that the difference is sufficiently unlikely to be assumed not to have occurred by chance.

Classification requirements in most problems facing the agricultural economist cannot be satisfied with such a technique. Suppose, for example, it is required that we estimate the elasticity of wheat output with respect to wheat price. To accomplish the aggregation required by this task requires that we group the various production situations in terms of opportunities producers have. Some would respond easily to price change. Others would find it impossible to respond. Logic suggests that the relevant characteristics are those which affect the slope of marginal cost

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functions of wheat output within firms in each group over the ranges of price and time specified by the problem.[1]

One might commence with the widely used "type-of-farming" areas.[2] Yet such a classification is demonstrably weak for research in the supply-response study. Boundaries are established with data reflecting decisions already made, not opportunities available. Moreover, the boundaries tend to be so drawn as to enclose geographically defined areas, whereas production opportunities may sometimes be more homogeneous with respect to nongeographic factors. That is, they may be found in noncontiguous areas. Finally, the use of a classification system that yields exclusive classes based on subjective judgment may result in a large (and unknown) percentage of misclassification.

When it is not possible to classify items on the basis of a single characteristic (variable), it is necessary to adapt some techniques to take account of the combined effects of the several variables that will distinguish the items by groups. In this paper we propose to explore three techniques to delineate production situations in the Northern Great Plains which favor (1) wheat production or (2) range forage production. The techniques are:

1. Linear multiple regression, where the dependent variable is expressed as percentage of acres in harvested wheat.
2. Linear discriminant function, which provides an index for classifying individual observations into exclusive categories.
3. Linear probability function, which provides a calculated probability of being a wheat producer for each observation, on which basis the two-way classification can be made.

An important facet of the problem is to be able to so use known information about individual ranches as to accomplish this taxonomic task with a known probability of error in misclassification. The extent to which this objective is met will influence the classification method in actual policy and production problems—for example, identifying "response-likely" firms as a basis for intensive study of the shifting process.

Description and Setting of the Problem

The Northern Great Plains is a region of extremes. Operators of farms and ranches in the area face a complex array of managerial decisions.

[1] This is a static formulation of the supply response problem. However, there is no conceptual reason for not including dynamic factors which change the marginal cost functions. Changes in technology and in quality of management have been suggested by T. W. Schultz in "Reflections on Agricultural Production, Output and Supply," *Journal of Farm Economics*, Vol. 38, No. 3, August, 1956, pp. 748-762.

[2] F. F. Elliott, *Types of Farming in the United States*, U. S. Department of Commerce, Bureau of Census, 1933.

But unlike most areas, where climatic, economic, and institutional changes create diverse shifts in land use, the typical Northern Great Plains dryland operator, if confronted with any shifting alternatives at all, is ordinarily restricted to grain and/or livestock production. Instead of adding new enterprises, attempts are often made to develop intrafirm flexibility.[3]

A decision as to which type of production will be followed will affect the operation of the farm or ranch for many years to come. A new supply of range forage and a foundation breeding herd cannot be acquired overnight. Acreage allotments for grains may be based on historical land use. Adjustments in production may therefore become very "sticky." Yet, during World War I wheat acreage expanded from 56 million acres in 1914 to 74 million in 1919 (harvested basis) and remained above 60 million throughout the 1920's.[4] During World War II, plantings of wheat were increased from 53 million acres in 1942 to 84 million in 1949.

Following this, wheat acreage tapered off briefly only to increase again to 78 million acres after the outbreak of Korean hostilities.[5] It is a matter of considerable concern that important margins of transference be located between wheat and competing uses of land. Margins of transference bounding the population of wheat farms are comprised of those which separate wheat farms from farms in which land is used (1) more intensively and (2) less intensively. Prominent in the latter group are stock ranches using land to produce range forage for livestock production.

Sources of data

The observational basis for this study consists of records taken in surveys made with two random samples: one of units in a predominantly wheat producing area in northeast and northcentral Montana,[6] and one of units in a predominantly range livestock area in southeast Montana, northeast Wyoming, and western South Dakota.[7] The combined samples provide data for 274 operating units.

[3] See Emery N. Castle, "Flexibility and Diversification as a Means of Meeting Price and Yield Uncertainty in Western Kansas," *Journal of Farm Economics*, Vol. 36, No. 2, May, 1954, pp. 273-284.

[4] Warren R. Bailey and Charles W. Nauheim, "Prospective Adjustments in Wheat Farming," U. S. Department of Agriculture, B.A.E., (Mimeo report prepared for distribution at 13th Annual Agricultural Outlook Conference, Washington, D.C., October 28, 1953), p. 1.

[5] Warren Bailey and Charles Nauheim, *op. cit.*, pp. 1, 4.

[6] See Darrell F. Fienup, *Resource Productivity on Montana Dryland Crop Farms*, Montana Ag. Exp. Sta. Mimeo Cir. 66, June 1952. The universe is defined as Montana Type of Farming Areas III and IV (Northeast Montana: spring wheat, nonirrigated) and VI and VII (North-Central Montana: mixed spring and winter wheat, nonirrigated).

[7] See James R. Gray and C. B. Baker, *Organization, Costs and Returns on Cattle Ranches in the Northern Great Plains*, 1930-1952, Montana Ag. Exp. Sta. Bul. 495,

Series in the following three variables were then compiled:

X_1 = total acres operated
X_2 = acres of land leased divided by acres of land owned[8]
X_3 = total annual precipitation in inches

Series in X_1 and X_2 were obtained from the survey schedules. Data for X_3 were obtained from published reports of the U. S. Weather Bureau. We emphasize at the outset that observations were drawn from units in known classes. The purpose of the following analytical alternatives is to so use this information as to obtain a device for classifying a newly observed unit on the basis of observations as in X_1, X_2 and X_3.

The Empirical Analysis

The linear multiple regression equation

The first step in the analysis was to fit by least squares a linear function of the form:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3,$$

where Y = per cent of total acres operated in grain harvested, and X_1, X_2, X_3 = size in acres, ratio of acres of land leased/acres of land owned, and annual precipitation in inches, respectively.

The calculated estimates of these parameters are:

$$Y = -4.72 - \underset{(0.00018)}{0.0014X_1} + \underset{(0.033)}{0.046X_2} + \underset{(0.36)}{1.67X_3} \qquad (1)$$

$$R^2 = 0.27 \qquad \bar{X}_1 = 4{,}387 \qquad \bar{X}_2 = 35.86 \qquad \bar{X}_3 = 16.88$$

The estimates of the standard errors of the regression coefficients are represented by the figures in the parentheses immediately below the parameter estimates. Although this linear combination of independent variables accounts for only 27 per cent of the variation in number of acres of wheat harvested, it is nonetheless significant with N = 274. Although b_2 (ratio of leased-owned land) does not appear significant at the 0.05 level of confidence, the coefficients for X_1 and X_3 (total acres and precipitation, respectively) could hardly have arisen due to chance. The signs of the coefficients b_1 and b_3 are consistent with logically based expectations.

December, 1953. The universe consisted of range livestock units which received at least 50 per cent of their gross income from sale of beef cattle, and which met certain other criteria, for areas listed in the text.

[8] As defined, this variable can be used only where there exists for all observations an acreage owned greater than zero. In classifying farms in populations including wholly leased farms, this variable would need to be defined differently (e.g., leased land/all land).

Although this equation may be used as a device for predicting acreage of wheat harvested, some critical problems arise when it is used as a classificatory device. In the first place, any selected percentage of land in grain harvested to be used as a discriminating index would appear to be purely arbitrary, particularly as a means of identifying marginal firms.

Second, it is extremely difficult to formulate *any* quantitatively expressed dependent variable for regression analysis which will be satisfactory for identifying marginal firms. For example, in this equation, the dependent variable measures harvested grain only and excludes fallow land as well as land used for other crops. These exclusions might be made trivial by the assumption that land in wheat is approximately twice that yielded by the predicting equation and by introducing a constant to allow for acreage loss between planting and harvest. Nonetheless, such definitional problems are critical in making a realistic classification. Third, this formulation does not provide a convenient means of distinguishing firms susceptible to changes in classification from those that fall without question into one of the two definite categories.

The standard linear discriminant function

As an alternative classification device, the next step was to calculate a linear equation of the form:

$$Z = a_1X_1 + a_2X_2 + a_3X_3.$$

The weights a_1, a_2, and a_3 are so determined as to maximize the ratio of the variance of Z between groups to the variance of Z within groups. Thus the index Z is an optimum linear discriminator between the groups. In applying the index, a critical level of Z ($\bar{A}$ in Figure 1) is set halfway between the means of Z for the two groups. Any item—in this case firm—with a Z index higher than the critical level is classified in one group; those with Z index values below the critical level are assigned to the other.

This technique is borrowed from the biological sciences where it was developed by R. A. Fisher in 1936 for the purpose of classifying plant specimens.[9] Two representative studies are mentioned as indicative of its application in the field of economics. Durand[10] used the technique

[9] R. A. Fisher, "The Use of Multiple Measurements in Taxonomic Problems," *Annals of Eugenics*, Vol. 7, Pt. 2, 1936, pp. 179-188. Fisher's work on discriminant functions was continued in two further papers published in the *Annals of Eugenics*; "Statistical Utilization of Multiple Measurements," Vol. 7, 1938, pp. 376-386; and "The Precision of Discriminant Function," Vol. 10, 1940, pp. 422-429.

[10] D. Durand, "Risk Elements in Consumer Installment Financing," Financial Research Program, Studies in Consumer Installment Financing 8, National Bureau of Economic Research, New York, 1941, p. 125.

to differentiate between good and bad loans on the basis of a body of financial data. Tintner[11] attempted to distinguish between prices of producers' goods and prices of consumers' goods by using information about the behavior of each class of goods throughout the business cycle.

In the case at hand, the computed estimate of the discriminating equation is:

$$Z = X_1 - 63.9X_2 - 1881.48X_3 \qquad (2)$$

where variables X_1, X_2, X_3 are identical in meaning to those in equation (1).

It must be ascertained whether or not a significant difference exists between the two samples for the function Z. This test of significance is summarized in Table 1.

TABLE 1. ANALYSIS OF VARIANCE OF Z BETWEEN AND WITHIN GROUPS

Source of variation	D.F.	S.S.	M.S.	F.
Within groups	270	.00671	.000025	
Between groups	3	.00305	.001016	40.92
	273	.00976	.001041	

Referring to the F table with $n_1 = 3$ and $n_2 = 270$, the function is seen to be significant at the .001 level. Also, by definition, no other linear combination will do a better job of discriminating between these two groups with the same data. A critical zone for Z can then be established as a region within which units are sensitive to shift in classification between those producing wheat and those producing cattle. This region is obtained by calculating a mean discriminating index for each group ($\bar{a}_w = -34{,}643.8$ and $\bar{a}_c = -23{,}537.1$ for wheat and cattle respectively) and by taking the unweighted mean of these two indexes to obtain $-29{,}050.5$[12] as the critical dividing line, $\bar{A}$, between the two groups.

The results from computing a Z for each of the 274 sample members are summarized graphically in Figure 1. This diagram shows the effects of the variables used in determining the margin of reclassification. The areas on either side of $\bar{A}$ (between $\bar{A}$ and $\bar{a}_c$ and between $\bar{A}$ and $\bar{a}_w$) are the crucial areas in this example. Firms falling into these zones are "sensitive" firms, susceptible to reclassification in the opposite direction from which they are classified according to values taken by variables in the discriminant function.

[11] G. Tintner, "Some Applications of Multivariate Analysis to Economic Data," *Journal of the American Statistical Association*, Vol. 41, 1946, p. 476.

[12] In further application, the index could be made easier to use by setting this value for Z equal to 100 and making appropriate adjustments in the coefficients.

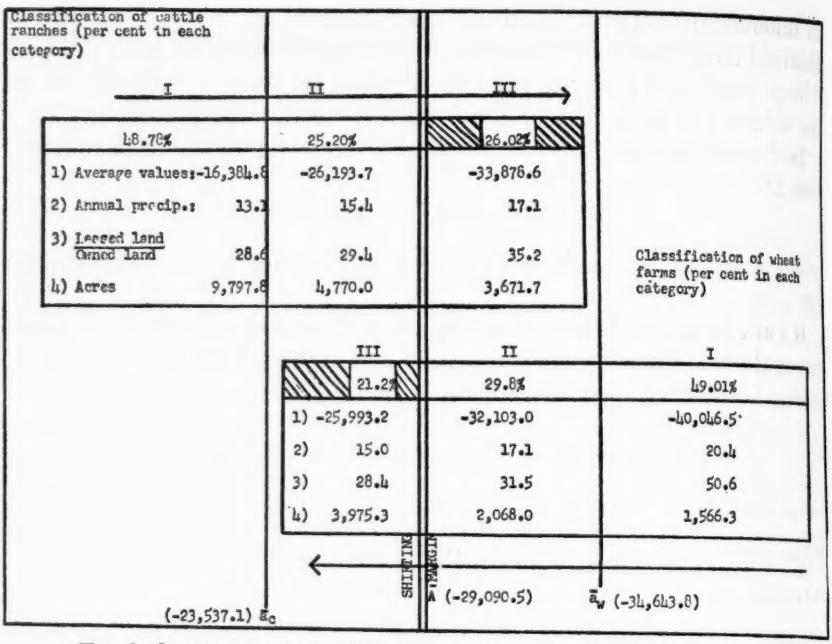

FIG. 1. CLASSIFICATION OF 274 SAMPLE RANCHES ON THE BASIS OF THEIR CALCULATED Z VALUES.

The upper and lower boxes represent the classification of cattle ranches and wheat ranches into three categories each on the basis of their calculated Z values. These categories, in both cases may be characterized as follows, on the basis of the data used:

Category I: Firms which can unquestionably be classified as cattle or wheat producing firms.

Category II: Firms which approach the "borderline," but still possess sufficient advantage in their own area to remain there.

Category III: "Borderline" cases which are characterized as susceptible to reclassification inasmuch as Category III for wheat (cattle) closely parallels average conditions for Category II for cattle (wheat).[13]

About one-fourth of the cattle ranches overlap into Category II of wheat farms and about one-fifth of the wheat farms overlap Category II of cattle ranches. The difference suggests that of units sensitive to shift, more have in fact shifted to wheat production than to range forage and cattle production. Over-all, the function is seen to have classified approxi-

[13] With one notable exception: the average acreage for cattle producing units which are "borderline" cases is approximately 1,500 acres greater than for wheat producing units falling into this same category.

mately 77 per cent of the 274 sample members into the group to which they belong.

One variable deserves brief additional comment. One could infer from some of the literature that yield might react as a linear function of moisture, over a limited range which has as its lower limit the minimum amount of moisture needed for plant survival.[14] If the average precipitation in cattle ranch Category I is arbitrarily raised from 13.12 to 20 inches, all other factors held constant, the value of Z would rise sufficiently to result in classification of these units as wheat farms. However, average precipitation in cattle ranch Category II need only be raised from 15.35 inches to about 17.5 inches to overlap into the wheat producing area. Although this is a rather shaky basis from which to assert that Z might possibly be a nonlinear function of the precipitation variable, it might be worthwhile to consider recomputing similar functions in this problem area with a transformation of the precipitation variable.

As shown previously the linear discriminant function provides a much more efficient and accurate classification in this illustration than does the regression equation as previously formulated. Also, the use of the discriminant function avoids the problem of defining a quantitatively expressed dependent variable, as in regression analysis. The theoretical similarities between the two techniques are, of course, substantial and have been well summarized by Kendall.[15] All that needs to be noted here is that the coefficients in both computed equations are of approximately the same relative magnitude and thus have approximately the same impact upon the outcome in each equation.[16]

The linear probability function[17]

The third linear formulation of the same three variables, known as a linear probability function, was then computed. This formulation involves the computation of a linear equation which will provide a calculated probability that any given unit belongs in a specific category.

We define a unit as a cattle or wheat ranch if the dependent variable, Y, a dummy variable, is, respectively, 0 or 1. The linear probability function is then easily obtained as the least squares regression:

$$Y = c_0 + c_1X_1 + c_2X_2 + C_3X_3.$$

[14] E.g., see O. R. Mathews and John S. Cole, "Special Dry Farming Problems," *Soils and Men*, U. S. Department of Agriculture Yearbook, 1938, p. 684.

[15] Kendall, Maurice G., *The Advanced Theory of Statistics*, New York: Hafner Publishing Co., third edition, Vol. 2, 1951, pp. 344-346.

[16] If the regression equation were transformed by adding the constant term to both sides of the equation and by dividing through by the leading term (the coefficient of X_1), then the signs would be the same for the coefficients in both equations also.

[17] This section is based on Daniel B. Suits, "Linear Probability Functions and Discriminations," discussion paper of the Research Seminar in Quantitative Economics, University of Michigan, October, 1957.

The calculated value of Y for any firm is then defined as the numerical probability that it is a wheat producing firm.

With a probability of one-half serving arbitrarily as the discriminating index, those units with a calculated probability of more than one-half would be classified as wheat ranches; those less than one-half would be classified as cattle ranches.

The parameter estimates for this formulation are:

$$Y = -.28 - .000028X_1 + .0018X_2 + .05X_3 \qquad (3)$$
$$\qquad\quad (.0000043) \quad (.00077) \quad (.007)$$
$$R^2 = .31$$

Adding the constant term to both sides and dividing the entire equation through by the coefficient of X_1, we obtain

$$-27{,}845 = X_1 - 63.92X_2 - 1{,}881.48X_3 \qquad (3a)$$

The coefficients of X_1, X_2 and X_3 are now *identical* with those of the discriminant function showing that the relative weights assigned the variables are exactly the same for the two functions. The critical value of $-27{,}845$ differs from the $-29{,}090.5$ assigned by the discriminant function. Hence, the discriminating index for the linear probability function would tend to classify more operators in the wheat category than does the discriminant function. The difference in the discriminating margins arises because the critical level of Z in the discriminant function is established empirically by the samples. The discriminating value of the index yielded by the probability function is set *a priori*. In general, they will not agree. Suits discusses in detail the possible reasons for differences in the final classification in comparing the two techniques. He also sets forth the foundation of the equivalence of the coefficients in both types of equations.[18]

In comparison with the computed regression equation, it will be noted that the coefficient of X_2 (ratio of leased land to owned land) is now significant at the 0.05 level of confidence, and that the R^2 has increased by a slight amount. On the basis of the standard errors we may conclude that this linear formulation may be used to predict the probability that any ranch chosen randomly from our population would be a wheat ranch.

The important thing to note, however, is that despite a slightly different assignment, the probability formulation is for all intents and purposes identical to the linear discriminant function. The probability formulation also avoids the difficulty that arises in defining a relevant dependent variable in ordinary regression analysis such that an objective classification can be made. Moreover, there is more meaning in a calculated prob-

[18] Daniel B. Suits, *op. cit.*

ability number for many areas of economic analysis than in a number calculated for the sole purpose of making a dichotomous classification.

Summary and Conclusions

We have attempted to examine a classification problem which, on the surface, seemed rather intractable. Three related tools of discrimination were applied in a rather summary and cookbook fashion, and the results compared:

1. *Linear regression:* this technique involved the computation of a value for the dependent variable that could be used to classify items into two groups. In the formulation presented, the equation served to aggregate the acres of wheat harvested for all of the 274 ranches, and on the basis of three independent variables, predict how many should in turn be parceled back to each one. But any classification, in this example at least, would have to be purely arbitrary as between cattle and wheat ranches.

2. *Linear discriminant function:* this method provides a device with which a new observation can be taken at random and placed either in the wheat box or the cattle box based on an empirically determined function.

3. *Linear probability function:* this method provides a calculated probability that any given observation would be a wheat farm. Having obtained this information, we could proceed to classify observations into two groups on the basis of the calculated probability that each observation would be a wheat farm. Since the calculated probability that any given observation will be a wheat farm is meaningful in and of itself, this formulation is clearly preferable to the linear discriminant function.

No pretense is made that the foregoing analysis constitutes an adequate treatment of the real classification problem—that of delineating firms sensitive to shifts between wheat and range forage production in the Northern Great Plains. For example, one might criticize the inclusion of objective and behavioral factors in the same discriminating equation. Perhaps the analysis might be improved by using only these factors which the farmer has to take as given and which cannot be changed in a substantive fashion by his own behavior.[19] The shortcomings of the analysis should not detract from the purpose of the paper, however, which was to demonstrate the application of these classificatory devices in the field of agricultural economics. Within the general problem area, a fruitful area of investigation might be that of adapting these and related techniques to the task of locating "boundary situations" and defining "type-of-farming" areas. This approach might provide the basis for selecting noncontiguous areas within a class with demonstrable criteria.

[19] Yet it might be argued that in many real situations operators in the Northern Great Plains can over fairly long periods of time do little more about size of firm and leased acreages than they can about precipitation.

ECONOMICS OF ESTABLISHING A SOIL CONSERVATION PROGRAM ON A BEEF FARM

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MANY studies show that soil improvement programs can increase annual farm profits after a few years. But few studies show how such programs affect farm income during the period of establishment.

Major soil improvement programs often require several years to pay for themselves if labor and capital are allowed prevailing rates. On many farms, costs of liming cropland may not be completely recovered until a meadow crop can be produced and marketed through livestock. Several years usually are required before benefits of permanent pasture improvement are fully realized. Alfalfa meadows cannot be expected to increase corn yields until sufficient time has elapsed to raise them and then plow the residues under.

This paper summarizes a study designed to determine whether a beef breeding herd under top grade management could finance a major soil improvement program in southeastern Ohio. This type of farming was selected to give some answers to questions concerning the possibilities of buying low priced land and improving it for the production of beef.[1] A breeding herd was selected for two reasons. Cows usually consume much higher proportions of hay and pasture than feeder cattle. Also, a breeding herd usually involves less risk than buying feeders. In southeastern Ohio, hay and pasture are the principal crops because most of the land is too steep for raising high proportions of grain.

How Study Was Made

Income figures from privately owned farms are rarely suitable for a study of this type because few farmers keep all other factors constant while adopting a soil improvement program. In recent years, farmers have adopted many practices that have no relationship to improving soil productivity. A few examples include the use of better varieties and more effective control of weeds, insects and diseases. Unless all other factors remain the same over a period of time, changes in income on actual farms cannot be attributed solely to better soil management.

In this study, the economics of establishing a major soil improvement program was determined by farm budgeting procedures. This method

[1] Costs and returns when dairy cows are used are given in the following publication: Blosser, R. H., *Economics of Building Up a Run-Down Dairy Farm in Southeastern Ohio,* Ohio Agricultural Experiment Station, Research Bulletin 784, December 1956.

produced income figures that changed only as a result of the program under consideration. Necessary input-output relationships were obtained from the best research data available. Detailed calculations included crop production, livestock numbers, capital requirements, labor needs, receipts, expenses and net income. Each item was calculated for nine consecutive years of the program. Also, the same calculations were made for one of the recent years before any land management changes were made.

Calculations were made only for a nine year period to simplify the study as much as possible. No changes in agricultural technology were assumed during this time. Except for the soil improvement practices studied, other improved methods of production could be applied to the proposed system of farming as well as the present one. Agronomists at Ohio State University think a nine year period is long enough practically to maximize meadow and permanent pasture yields. But grain yields might be expected to increase slightly beyond the ninth year. However, one or two more bushels of grain per acre would not change conclusions significantly, especially when the principal crop is forage.

Soils considered were Muskingum and associated types which are roughly representative of about 15 million acres of land in southern Indiana, southeastern Ohio, and the northern parts of Kentucky and West Virginia. These soils erode easily because of steep slopes that range from 10 to 30 per cent. Soils maps often show that more than half of the original topsoil has been lost from the cropland. Muskingum and associated soils are unglaciated and have developed from sandstone and shale. They are acid in reaction except where liberal amounts of lime have been applied recently.

How Crop Production Was Determined

Size of farm studied was 500 acres. This amount of land was calculated to be needed if a beef enterprise were used to employ a typical farm family full time. In determining size of farm to study, the following assumptions were made: available labor to be used on the farm would amount to almost 3100 hours a year; cropland and permanent pasture would be limed and fertilized according to agronomists' recommendations; and young stock would be sold at an average slaughter weight of 850 pounds.

Five hundred acres of contiguous farm land might be somewhat difficult to obtain because the average farm in southeastern Ohio is only about one-fourth this size. However, the United States Census shows that slightly more than 1 per cent of the farms in southeastern Ohio are larger than 500 acres. If smaller tracts were used only for beef production, family income would be less than this study indicates unless some off-

TABLE 1. LAND USE FOR 500 ACRE BEEF FARM

Land use	Acres	Per cent
Corn	22	4.4
Wheat	22	4.4
Oats	13	2.6
Meadow	75	15.0
Rotated land	132	26.4
Permanent pasture		
Suitable for improvement	120	24.0
Unsuitable for improvement	48	9.6
Woods	150	30.0
Miscellaneous	50	10.0
Total	500	100.0

farm income were obtained. However, part-time farmers on average size farms should be able to finance a major soil improvement program easier than full-time farmers on larger farms. Reasons include smaller investments in lime, fertilizer, and additional livestock. Also, a job in town often pays considerably more per hour than beef cattle. Today, many farmers in southeastern Ohio are able to obtain employment in nearby commercial industries.

Acreages used in calculating crop production are shown in Table 1. This distribution of crops was determined from census data, soils maps, and a recent beef study.[2] Although total farm area is considerably greater than the amount contained in the average hill farm in southeastern Ohio, percentage of land in the various crops is about the same.[3]

No reduction in the acreage of grain crops was assumed to be needed for soil improvement purposes if contour strip cropping were used on the steep slopes. Land use capability maps for southeastern Ohio show that about 70 per cent of the land classified as permanent pasture can be limed, fertilized, and mowed with modern farm machinery. But the remaining 30 per cent is unsuitable for improvement because of steep slopes and brushy growth.

Grain and hay production was calculated from three different crop rotations. Corn, wheat, and one year of meadow were assumed to be grown on 24 acres of bottom land. Corn, wheat, and two years of meadow supplemented with contour strip cropping were used on 56 acres of hill land. Oats and three years of meadow were assumed to be used on 52

[2] Shaudys, E. T. and J. H. Sitterley, *Costs of Producing Beef in Southeastern Ohio*, 1954, Ohio Agricultural Experiment Station Research Circular 45, April 1957.

[3] An attempt was made to use the actual acreages in crops on a specific farm. Soils maps and land use data were checked in six Soil Conservation District Offices to locate a satisfactory farm. This idea was abandoned because many farms were not mapped, and most farms that were mapped were too small. Therefore, a typical land use pattern for Muskingum soils had to be determined.

TABLE 2. YIELDS USED IN CALCULATING CROP PRODUCTION FOR 500 ACRE BEEF FARM[1]

Crop	Before improvement program	During improvement program		
		First rotation period	Second rotation period	Third rotation period
Corn, bushels	45	55	62	65
Wheat, bushels	20	23	25	26
Oats, bushels	30	35	38	40
Hay				
1st cutting, tons	1.0[2]	1.0[2]	1.4[3]	1.8[4]
2nd cutting, tons	—	.5[2]	.7[3]	1.0[4]

[1] Yields for the nine southeastern Ohio counties where Muskingum soils predominate were as follows for the 10 year period 1947–56: corn, 49 bushels; oats, 34 bushels; wheat, 22 bushels; and hay, 1.4 tons per acre.
[2] Timothy with some red clover.
[3] Red clover and timothy with some alfalfa.
[4] Alfalfa, clover, and timothy.

acres of hill land which was considered too steep for corn. Oats were used only to keep wheat acreages within current allotments. By using three different rotations, farmers could maximize grain production while improving crop yields.[4]

Yields used in calculating total production for the rotated land are shown in Table 2.[5] Crop yields before the improvement program was started were based on using no contour strip cropping and fertilizer applications of only 200 pounds per acre of 3-12-12 analysis on corn and small grain. None was used on meadows. Applications of lime averaged only one-half ton per acre every four years. Yields for the 24 acres of bottom land were assumed to be the same as produced on the hill areas because high water occasionally causes some crop losses along the the small streams. Also, the bottom soils had a smaller percentage of meadows in the rotation than the hill land.

Crop yields under the improvement program were based on using contour strip cropping on the steep slopes and heavy applications of fertilizer and lime. Corn, wheat, and oats were assumed to be fertilized with 250 pounds per acre of 5-20-20 analysis. First year meadows were top dressed with 200 pounds per acre of 0-20-20 fertilizer after making the first crop of

[4] These rotations were based on soil capability classes used by personnel of Soil Conservation Districts to develop cropping programs to control erosion and improve soil productivity.

[5] These yields are estimates made by the author and Extension Agronomists at Ohio State University. Estimates were based largely on yields given in Table 3, page 9 of the following publication: Blosser, R. H., *Economics of Soil Conserving Practices on Muskingum and Associated Soils in Ohio,* Ohio Agricultural Experiment Station, Research Bulletin 746, August 1954. Estimated yields were used because no detailed experimental data were available for the improvement period discussed in this study.

hay. Lime was assumed to be applied according to needs as shown by tests for Muskingum soils. Specific amounts included an initial application of four tons per acre of agricultural ground limestone; two tons were used for the next rotation; and one ton each rotation was used thereafter for maintenance.

Rotation pasture yields were based on the type and amount of hay assumed to be raised. Permanent pasture yields were determined from experimental data.[6] Permanent pasture yields before improvement were based on using no fertilizer or lime. Yields during the improvement program were based on using three and one-half tons per acre of agricultural ground limestone followed by one ton every four years, and 425 pounds per acre of 0-20-20 fertilizer every three years. Also one mowing each year was assumed to be made to control weeds and brush.

Grain production in the ninth year of the program was calculated to be approximately 40 per cent higher than the amount produced before any soil improvement was made. The amount of hay harvested was estimated to increase from 75 to 149 tons. Fourteen tons of this increase came from harvesting a second cutting on 14 acres. Permanent pasture yields were approximately doubled during the period studied. To provide a well-balanced pasture program throughout the summer months, all meadows were assumed to be pastured after making the first crop of hay, except 14 acres located between corn strips. A second cutting of hay was assumed to be made instead of pasturing between corn strips to eliminate the need for constructing temporary fences and providing watering facilities for livestock. Meadow strips next to wheat could be pastured after the first cutting of hay without constructing temporary fences.

Income under Top Management

Income figures in Table 3 are based on top grade management because studies often show that beef cattle are not profitable under average farm conditions.[7] If top grade management cannot produce some profits, soil improvement programs cannot be financed out of current farm earnings. Top grade management included the following: (1) a minimum investment in machinery, fences and buildings; (2) efficient use of labor; (3) high crop yields; (4) a well-balanced pasture program; (5) a 93 per cent calf crop; and (6) slaughter cattle prices for animals grading good.

Estimated capital investments in Table 3 are based on 1951-55 prices. For the ninth year of the program, land values were increased by an amount equal to the estimated cost of replacing the unused lime remaining in the soil. Below average land might be purchased for less than the

[6] Rotation and permanent pasture yields were taken from pages 6 and 7 of the following publication: Dodd, D. R., *Good Pasture,* Ohio Extension, Bulletin #345, August 1954.

[7] Shaudys, E. T. and J. H. Sitterley, *op. cit.*

TABLE 3. CAPITAL INVESTMENT, LIVESTOCK NUMBERS, RECEIPTS, EXPENSES AND CASH RETURN TO LABOR FOR A 500 ACRE BEEF FARM

	Before improvement	During improvement	
		1st year	9th year
Capital investment			
Land	$15,000	$15,000	$19,800
Buildings	10,000	10,000	8,400
Machinery	5,500	5,500	5,500
Livestock	9,100	9,100	15,700
Total	39,600	39,600	49,400
Livestock numbers[1]			
Cows	32	29	55
Feeder cattle	24	18	43
Market hogs	15	48	0
Receipts			
Beef	$ 5,596	$ 4,232	$ 9,892
Hogs	600	1,920	0
Wheat	804	772	1,144
Total	7,000	6,924	11,036
Expenses			
Feed	482	580	725
Machinery	1,375	1,407	1,649
Lime	105	1,470	390
Fertilizer	285	1,116	1,291
Other	3,011	3,038	3,721
Total	5,258	7,611	7,776
Cash return to all labor	1,742	−687	3,260
Hours of labor used	2,223	2,298	3,068
Cash return per hour of labor	.78	−.30	1.06

[1] Based on using July 1 for beginning and closing inventories.

values used in this study. But clearing operations might make the final cost even higher.

Buildings were depreciated $200 annually. The assumption was made that no more buildings would be needed as a result of the soil improvement program. Usually 500 acres of land will have more buildings than needed for beef production, especially if several farms have been combined recently. Therefore, some buildings may need to be sold to reduce the valuation to the amount used. More buildings would raise capital investments, but a second house might increase income in the form of rent. If a barn were needed, a pole type structure could be built at a nominal cost by using timber produced on the farm. Better than average buildings and more than the needed number could increase investments several thousand dollars. Higher building investments would produce a smaller net income than shown in this study.

Fences were valued at $1000 throughout the period studied. New construction and repairs were assumed to offset annual depreciation. To keep investment this low, barbed wire and home-grown posts would have to be used. Woven wire fence would about double this valuation.

Machinery investment was kept down to $5500 by assuming it would be about half worn out, and some exchange of work and equipment would

be made with neighbors. Annual investment was held the same by assuming some better pieces of machinery would be bought occasionally. A full line of almost new equipment would more than double machinery values used.

The amount of hay and pasture the farm would produce was used to determine the number of beef cows, replacements, and feeder cattle that could be kept. No other forage consuming livestock was considered. Many farmers in southeastern Ohio object to keeping sheep because of losses caused by dogs. Also, sheep require considerably better fences than beef cattle. Hogs were used to consume all of the corn not needed by the beef enterprise. This procedure was based on the assumption that net income would be higher if grain were fed to hogs instead of sold. Also, hogs would require less capital and involve less risk than purchasing feeder cattle to consume the surplus grain.

No consideration was given to the economics of purchasing grain to feed additional hogs during the early years of the soil improvement program because southeastern Ohio is a deficit grain area. Consequently, a premium has to be paid for hauling corn into this area. Also, the purchase of grain would have increased capital needs at a time when heavy expenditures were being made for lime and fertilizer. Sales from wheat included all of the crop except a small amount fed to hogs. The entire crop of oats was assumed to be fed.

Calculations showed that beef cows could be increased about 70 per cent from the additional feed produced by the soil improvement program. Small amounts of corn should be available each year for fattening hogs until the seventh year of the program. But from then on, the beef herd would require all of the corn the farm would produce. Cow numbers were reduced slightly during the first year of the program to provide feed for replacements to build a larger herd. The number of feeder cattle for sale was reduced for the first two years because more young stock was held for breeding purposes. Feeder cattle numbers were based on a 93 per cent calf crop raised to marketable weights and 15 per cent annual replacement of old cows. Feed requirements for each animal were based on Ohio livestock feeding standards.[8]

[8] Cow and calf to weaning were allowed 1.8 tons of legume hay, .5 tons of oats and wheat straw, and 3 bushels of grain. Feeder calves from weaning to market were allowed .5 tons of legume hay, 35 bushels of grain and 300 pounds of protein supplement. Replacement heifers from calves to freshening were allowed 2.7 tons of legume hay, 5 bushels of grain and 200 pounds of protein supplement. Market hogs (including the sow's share) weighing 200 pounds were allowed 14 bushels of corn, 2.5 bushels of wheat and 80 pounds of protein supplement. These feed requirements were taken from pages 21-25 and 12-15 of the following publication: Sitterly, J. H., *Rates of Feed Consumption by Livestock*, Department of Agricultural Economics and Rural Sociology, Ohio State University, Extension Bulletin #308, Revised 1955.

Cash receipts in the ninth year of the program were about 60 per cent higher than the estimated amount before any soil improvement was made. Receipts from cull cows and slaughter cattle were calculated to decline for the first two years because more young stock would be needed to build up brood cow numbers. Higher corn yields would increase receipts from hogs for the first five years of the soil improvement program. But no hogs were assumed to be raised from the seventh year on because all corn would be needed for the expanded beef enterprise. Wheat sales increased about 40 per cent during the period studied. A slight decline occurred in the first year of the program because of feeding more hogs.

Prices used in calculating receipts were as follows: beef for slaughter $24 per hundred pounds after deducting hauling charges; cull cows $14 net per hundredweight; hogs $20 net per hundred pounds; and wheat $2 per bushel. Hog and wheat prices were averages received by Ohio farmers for the five year period 1951-55. Since no fat cattle prices were available for Ohio, prices used for slaughter cattle were averages for animals grading good on the Chicago market for 1951-55. Prices for this kind of cattle were used because top level management and a better than average herd were assumed. Calves were assumed to be born during the early part of April, weaned from October 15 to November 15, and fed in dry lot until sold in July. When adjustments are made for increases in the general price level, beef cattle prices also average about the same for the 10 year period 1946-55 as the 5 year period 1951-55.

During the first four years of the soil improvement program, annual cash expenses were about $2500 greater than before any changes were made. But from the fifth year on, annual expenses were about $2000 higher. Heavy applications of lime and fertilizer accounted for most of these increased costs. Distribution of labor should create no serious problems, except during the hay making season. In this study, 75 hours of hired labor were estimated to be needed before any changes were made. But in the ninth year of the soil improvement program, 150 hours of hired labor were calculated to be needed to help harvest 135 tons of first cutting hay. Cost of this labor was figured at $1 an hour.

Calculations in Table 4 show why the first few years of a soil improvement program may be difficult to finance out of current farm earnings. Until about the fifth year of the program, annual cash returns to labor will be less than before any changes were made. About seven years will be needed to increase hourly returns to labor because labor requirements increase as more crops and livestock are raised.

These calculations are based only on cash receipts. Inventory increases were omitted because they could not be withdrawn from the farm business and at the same time used to produce more income later. Labor

TABLE 4. CALCULATED NET INCOME AND LABOR REQUIREMENTS FOR 500 ACRE BEEF FARM

(Based only on cash receipts; inventory increases omitted)

Year	Return to labor and capital	Return to labor only	Return per hour of labor	Hours of labor required of farm family[1]
0[2]	$3326	$1742	$.78	2223
1[3]	897	−687	−.30	2298
2	1040	−620	−.26	2427
3	1385	−351	−.14	2556
4	1860	56	.02	2660
5	3549	1661	.59	2807
6	3940	2016	.70	2899
7	4310	2358	.80[4]	2963
8	4848	2876	.94	3046
9	5236	3260	1.06	3068

[1] Includes miscellaneous labor used for building fences, marketing farm products, repairing fences, buildings, machinery, etc.

[2] Before soil improvement program was established.

[3] Years 1–9 represent period of improvement.

[4] A financial statement for the first six years (until annual receipts would be sufficient to pay labor and capital average rates or more) showed the following: total cash receipts, $49,576; expenses including a payment of $.75 an hour for labor and 4 per cent interest on capital, $59,235; increase in capital invested, $8500; loss $1159.

needs for crops were determined from average Ohio requirements adjusted for southeastern Ohio. Labor requirements for livestock were calculated from averages for the state as a whole.[9]

Annual returns were calculated two different ways to show whether they would be sufficient to finance the soil improvement program as it was established. One method omitted any interest charge. If a farmer owned all capital needed, no cash outlay would have to be made for interest payments. Consequently, returns to capital could be used to pay current expenses, if needed. The other method was based on paying an average interest charge of 4 per cent on the valuations placed on land, buildings, machinery and livestock.

If $2500 plus the use of a house were used annually for family living, some off-farm income would be needed to finance the first four years of the program, even if all capital were owned and no interest charge were made for its use. If 4 per cent interest were charged against all capital used, considerably more off-farm income would be needed to finance the first six years of the program. Stated somewhat differently, if $2500 were used annually for family living, no payments on interest or principal could be made out of farm earnings before the fifth year.

[9] Sitterley, J. H., *Measures of Farm Work, Rates of Performance and Time Requirements for Common Farm Operations and Tasks*, Department of Agricultural Economics and Rural Sociology, Ohio State University and Ohio Agricultural Experiment Station, Mimeograph Bulletin No. 221, October, 1950.

From 1951-55 Ohio farm wage rates averaged about $.75 an hour plus the use of a house. If all labor were paid this amount and capital were allowed 4 per cent interest, about seven years would be needed before cash receipts and increases in inventory would be sufficient to pay all previous costs of the soil improvement program. This would be about two years longer than the time needed to increase annual income above the yearly amount received before any changes were made. These calculations are based on producing 195 pounds of beef per acre of cropland and improved permanent pasture,[10] 1951-55 production costs, and a price of $24 net per hundredweight for slaughter cattle.

If capital were borrowed, additional income would be needed to make repayment on principal. Since lending agencies usually require some repayment on loans each year, most farmers would have difficulty borrowing any sizable amount of money during the early stages of the program just described. Therefore, they might have to use a slow rate of improvement to keep additional expenditures to the minimum. Such a procedure, however, would reduce annual receipts below calculations in this study and delay the time when the program would yield the greatest income.

How then could such a program be financed? It might be done by using savings on which no interest had to be paid. An off-farm job might be used to help support the family for the first few years of the program. At that time labor requirements would be about 700 hours less than needed in the ninth year. Also, the level of family living might be reduced to the bare necessities until additional returns were greater than additional costs.

Additional Economic Considerations

Income figures for the 500 acre farm were based on an annual production of 195 pounds of beef per acre in the ninth year of the program. Acreages used in calculating this production included only improved permanent pasture and cropland providing feed for the beef herd. Unimproved permanent pasture was omitted because it consisted principally of briars, broom sedge, poverty grass and brush. This type of vegetation could not be improved because it was located on slopes too steep to lime, fertilize, and mow with modern farm machinery. To produce 195 pounds of beef per acre of cropland and improved permanent pasture, the following acreages of crops would be needed for each brood cow in the herd: grain .6, hay and rotation pasture 1.4, improved permanent pasture 2.2, or a total of 4.2 acres. These figures include feed required by breeding bulls, calves and enough young cattle to replace about

[10] This figure was determined by dividing the number of pounds of slaughter cattle and cull cows sold in the ninth year of the program by the number of acres of grain, hay and improved pasture fed to the beef enterprise in that year.

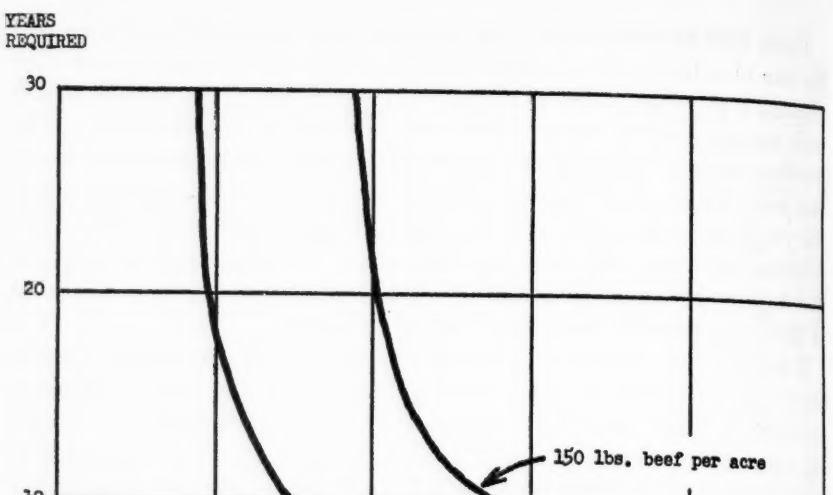

FIG. 1. YEARS REQUIRED BEFORE SOIL IMPROVEMENT PROGRAM WILL PAY FOR ITSELF OUT OF CASH RECEIPTS AND INVENTORY INCREASES WHEN DIFFERENT PRICES AND PRODUCTION LEVELS ARE USED.

15 per cent of the old cows each year. If unimproved permanent pasture were included in the feed supply, about .9 acres more per cow would have to be added. This would reduce annual beef production to about 160 pounds per acre.[11]

How would conclusions change if only 150 pounds of beef could be produced per acre? Also, how would lower or higher beef prices than the average for 1951-55 affect the length of time needed to pay for the soil improvement program? Figure 1 shows the number of years required before the soil improvement program will pay for itself out of cash receipts and increases in inventory when different beef prices and levels of production are used. Expenses were calculated on the basis of 1951-55

[11] This production checks closely with the highest levels of efficiency shown in the following publication: Miller, Lewis R. and John H. Sitterley, *A Study of the Commercial Beef Breeding Enterprise on Selected Farms in Southeastern Ohio in 1950*, Department of Agricultural Economics and Rural Sociology, Ohio State University, Mimeograph Bulletin No. 239, March, 1953.

production costs. They included a charge of $.75 an hour for labor plus the use of a house and 4 per cent interest on all capital used.

If annual production of beef is assumed to be 195 pounds per acre of cropland and improved permanent pasture, and slaughter cattle sales average $23 net per hundred pounds, about 10 years will be needed to finance the soil improvement program out of cash receipts and increases in inventory. A price of $24 per hundredweight will reduce the time required to seven years. If the average price of slaughter cattle were less than $21 per hundred pounds, farm earnings would not be great enough to pay all costs of the soil improvement program with this level of beef production.

If annual production of beef averaged only 150 pounds per acre in the ninth year of the program, slaughter cattle would have to sell for about $25.50 net per hundred pounds to pay all costs within 10 years. A price of $28 per hundredweight would be needed to reduce the required time to six years. Farm earnings would not be sufficient to pay all additional costs if the average price of slaughter cattle were below $23. These figures may look somewhat discouraging, but calculations also show that if no soil improvement work were done, labor and capital could not be paid average rates unless slaughter cattle sold for more than $23.50 per hundred pounds. Therefore, the soil improvement program did more to increase volume of business than raise unit returns to labor and capital.

A soil improvement program can increase net income by increasing the returns per unit of labor and capital and by providing more hours of work and greater use of capital. Before any changes were made, hourly returns to labor were $.78 for 2223 hours based on a production level of about 110 pounds of beef per acre. But in the ninth year of the soil improvement program, hourly returns to labor would be $.82 for 2705 hours at the 150 pound level of production. Under these conditions most of the financial gains would come from increasing volume of business. With beef production at the 195 pound level, hourly returns would be $1.06 for 3068 hours of labor. Financial gains, in this case, would result from higher returns per hour as well as greater use of labor.

Previous calculations do not apply to land that is too rough to produce corn from the standpoint of erosion control. Suppose permanent pasture, meadows and some small grain were the only crops that could be raised and that young stock was sold as feeder calves weighing about 450 pounds. Under these conditions about 750 acres of land was estimated to be needed to provide the same labor requirements as the 500 acre tract. This larger tract of land should support about three-fourths more brood cows and require about 30 per cent more capital than the smaller acreage. But time required to finance the soil improvement program out of farm

earnings on the 750 acres was calculated to be about twice the amount needed on the 500 acre farm because one-half more land improvements would have to be financed with about the same annual gross receipts. These relationships are based on a slaughter cattle price of $24 per hundred pounds and a feeder cattle price of $25.

The question might be asked how beef cattle can pay for a soil improvement program when cost of production studies often show losses for the beef enterprise. This apparent discrepancy can be explained in several ways. Cost of production studies are usually based on the practices used by *average* beef farmers. This study was based on above average practices which included high seasonal prices for cattle grading good, a minimum investment in machinery, fences and buildings, efficient use of labor, a well-balanced pasture program, high crop yields, a 93 per cent calf crop and no serious droughts.

In this study no values were assigned to specific crops in figuring costs of producing beef. Only actual expenses for the farm as a whole were used. This procedure placed a lower value on the cost of feed than used in most cost of production studies which use market prices for grain and hay. Market prices may often be too high for such crops as hay because an established outlet does not exist for many farmers. Therefore, beef cattle are often kept to market crops that otherwise would produce little income.

ECONOMIC ASPECTS OF THE EFFECTS OF FERTILIZERS, SOIL MOISTURE AND RAINFALL ON THE YIELDS OF GRAIN SORGHUM IN THE "SANDY LANDS" OF SOUTHWEST KANSAS*

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DURING the last two decades farmers have increased the use of commercial fertilizers many-fold. In spite of an upward trend in fertilizer purchases, many farmers, particularly in semi-arid regions, have not been using any fertilizers.[1] In these regions the effects of fertilizers on different crops produced under varied climatic and soil moisture conditions have not been explored as fully as in other regions, or the fertilizer experiments that have been carried out proved to be unreliable for crop yield predictions.

Farmers, cognizant of the fact that responses to fertilizer depend on other factors with which the fertilizer is combined, are hesitant to accept the rate of fertilizer recommendations at face value. They know that fertilizer experiments have often been discarded or have not been completed because lack of soil moisture made it impossible for the crop to produce grain.

Soil moisture is one of the important factors for the satisfactory production of crops. It cannot be ignored in fertilizer studies, particularly in areas noted for extreme variations in annual rainfall. Adverse weather conditions that cause large variabilities in soil moisture also make crop responses to fertilizer difficult to predict because the soil moisture and fertilizers are interdependent. During years of adequate moisture, yield responses are better than during dry years.[2]

Lack of forehand knowledge, not only about prices but also about yields, poses a serious problem to farm managers in western Kansas. The recent cost-price squeeze aggravates the problem even more. Mere intuitive judgments and rules of thumb often used for solving management problems are in many cases unreliable criteria for achieving most profitable use of resources. Commercial farming is passing into the category of big private business and mistakes prove to be costlier each day. Farm business needs answers to different problems in the form of more ac-

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[1] In western Kansas, for example, less than 5 per cent of crop acreage is fertilized. Kansas State Board of Agriculture, Kansas Fertilizer Trends, Report No. 307.

[2] See W. L. Parks, "Methodological Problems in Agronomic Research Involving Fertilizer and Moisture Variables," *Economic Analysis of Fertilizer Use Data*, Iowa State College Press, Ames, 1956, p. 113.

curate, quantitative statements substantiated by results of experiments.

The purpose of this experiment was to provide better answers than are now available with respect to some of the factors affecting grain sorghum production. Factors believed to be important determinants of the yields of grain sorghum have been used in this investigation: (1) depth of soil moisture at seeding time, (2) rainful during the growing season, (3) nitrogen and (4) phosphorus. Thus the primary objective was to predict the yields of grain sorghum under varied soil moisture and fertilizer conditions and thereby to specify optimum rates of fertilizer application under different moisture and fertilizer/grain sorghum price situations.

Location, Nature of the Experiment and Data

Cooperative studies involving moisture conditions and the use of fertilizer on grain sorghum have been conducted since 1951 on sandy soils in southwest Kansas. Weather conditions such as soil blowing and drought have made it impossible to harvest all locations where fertilizers were applied. For this reason the results reported herein are based on the data compiled over the past six years.

The depth of soil moisture was measured at seeding time and the rainfall during the growing season was recorded at each location. Fertilizer application was made at planting time, placing the fertilizer below and to the side of the seed by means of a continuous belt side dressing apparatus mounted on an Allis "G" tractor. All locations were lister-planted by the cooperator.

Experimental data that form the basis for this study are reported in Table 1. The data show the yields of grain sorghum obtained for various fertilizer rates and moisture conditions. Fertilizers used were ammonium nitrate and triple superphosphate. These two nutrients were applied alone and in combination as shown in Table 1. The experiment included 14 fertilizer treatments and eight different levels of moisture. The number of replicates varied. There were four or five replicates per treatment and the experiment includes a total of 382 observations.

The experimental data and statistical analysis substantiate the widely accepted proposition that available soil moisture at seeding time is one of the main factors determining the yield of grain sorghum. While rainfall during the growing season affected the yields favorably, its effects were less than those obtained from the soil moisture stored at planting time. Grain sorghum can grow and produce some grain under limited rainfall conditions if soil moisture at seeding time is adequate.

Grain sorghum response to fertilizer varies with moisture conditions. The deeper the level of moisture, the greater the response to fertilizer. Responses obtained from ammonium nitrate were significant while those

TABLE 1. GRAIN SORGHUM YIELDS (BUSHELS) PER ACRE FOR DIFFERENT FERTILIZER TREATMENTS AND DIFFERENT GROWING SEASON RAINFALL AND DEPTH OF SOIL MOISTURE AT SEEDING TIME CONDITIONS ON THE "SANDY LANDS" OF SOUTHWEST KANSAS IN 1951–56

[illegible] to specified combinations of nitrogen (N) and phosphorus (P_2O_5) in pounds

TABLE 1. GRAIN SORGHUM YIELDS (BUSHELS) PER ACRE FOR DIFFERENT FERTILIZER TREATMENTS AND DIFFERENT GROWING SEASON RAINFALL AND DEPTH OF SOIL MOISTURE AT SEEDING TIME CONDITIONS ON THE "SANDY LANDS" OF SOUTHWEST KANSAS IN 1951–56

Depth of Soil Moisture Inches	Rainfall, Inches	Bushels of grain sorghum per acre in response to specified combinations of nitrogen (N) and phosphorus (P_2O_5) in pounds																					
		N P_2O_5 0 0	N P_2O_5 0 40	N P_2O_5 20 0	N P_2O_5 20 40	N P_2O_5 40 0	N P_2O_5 40 40	N P_2O_5 80 0	N P_2O_5 80 40	N P_2O_5 20 80	N P_2O_5 40 80	N P_2O_5 0 80	N P_2O_5 80 80	N P_2O_5 20 25	N P_2O_5 80 100								
24	3.8	3.1	6.0	7.6	11.7	15.2	21.9	16.4	11.5														
		8.2	14.3	22.0	10.2	12.2	14.3	16.0	20.0														
		11.3	10.7	8.4	9.0	11.2	5.0	6.8	6.7														
		3.7	9.7	8.0	3.2	9.6	3.9	5.3	15.2														
		1.2	5.5	2.8	3.2	3.5	1.8	6.4	5.2														
36	3.5	17.0	13.0	15.0	12.0	15.4	17.0	18.0	21.0	12.3	17.0	18.4	13.7										
		18.7	14.0	17.4	13.0	14.3	13.0	16.0	12.3	11.0	14.0	14.0	9.7										
		14.0	13.0	15.0	13.0	12.7	13.7	17.4	10.3	10.7	14.3	15.0	13.3										
		18.4	15.4	18.4	18.7	14.7	19.4	12.3	10.7	19.0	9.7	18.7	21.0										
36	5.0	14.2	12.8	7.3	9.7	9.5	10.1	7.5	13.4														
		10.8	16.0	26.5	18.6	25.8	27.4	13.9	11.9														
		5.1	9.8	6.6	21.4	13.9	13.2	3.1	5.5														
		13.0	13.3	11.7	18.2	16.9	13.7	11.9	13.4														
		11.0	16.3	13.9	15.6	12.1	20.1	7.4	10.8														
36	5.8	30.6	31.4			34.2	27.6	31.6	37.0		30.9	30.2	19.9	28.3	35.3								
		26.9	34.9			27.4	41.2	37.4	23.2		36.7	36.3	37.7	33.5	21.1								
		26.2	29.0			29.0	33.7	30.2	36.5		31.1	33.7	18.7	32.3	26.0								
		28.5	27.6			37.0	27.8	28.5	32.3		34.9	28.8	27.8	33.2	21.8								
		30.6	26.4			22.0	26.9	39.1	29.5		42.4	28.1	36.0	20.6	27.6								
48	2.0	31.5	30.1			38.2	40.3	44.7	41.5		38.5	29.5	42.3	37.7	18.7								
		31.2	28.9			43.5	41.2	40.9	41.5		43.8	33.3	38.2	34.7	29.5								
		24.8	25.4			38.0	39.1	39.7	40.9		37.8	33.9	39.1	30.7	37.1								
		28.0	29.5			32.7	31.0	40.9	27.2		35.3	32.7	30.4	29.5	28.6								
		29.8	29.2			35.0	33.6	25.4	32.1		27.7	31.5	26.0	29.2	25.7								
48	5.8	23.8	22.3	21.7	23.4	23.7	27.2	25.2	26.8														
		23.5	22.2	24.6	25.9	31.4	27.2	25.1	29.1														
		22.0	26.0	20.9	30.6	27.4	25.4	30.6	26.6														
		25.9	26.7	25.4	24.0	30.4	28.7	23.7	34.8														
		23.3	25.7	23.2	34.9	27.8	29.5	23.5	30.5														
48	12.0	28.8	30.7			54.0	51.5	58.9	55.8		52.8	31.3	64.4	43.8	27.9								
		30.7	41.4			48.8	53.4	61.6	60.4		50.3	34.4	61.3	47.5	48.8								
		38.6	32.8			49.4	50.0	54.6	60.7		51.8	32.8	60.1	42.3	42.9								
		28.5	45.1			45.1	58.6	62.2	51.8		56.1	40.5	62.9	41.1	47.8								
60	7.0	29.4	34.0	33.4	25.0	27.0	33.4	46.4	33.7	38.7	25.0	29.4	36.4										
		40.4	31.7	42.0	34.7	46.0	54.7	52.0	52.4	39.0	24.4	42.7	47.0										
		43.2	32.4	42.7	45.0	51.0	49.4	53.7	53.7	46.7	37.4	32.7	51.7										
		31.7	28.7	43.4	27.4	37.4	43.0	34.7	27.4	40.7	32.0	30.4	34.0										
		36.0	31.4	36.7	32.0	40.4	31.7	48.4	46.7	32.4	27.4	32.4	33.4										

obtained from super-phosphate were negligible. In fact, grain sorghum response to phosphorus was negligible, even at higher levels of moisture.

Response Curves

Since the forms of grain sorghum response curves or production functions are not known, the preliminary analysis included derivation of response curves of different types. This has been done in order to single out the type of function(s) which gives the most accurate yield predictions.

The forms of functions derived from the basic data are these:

I. $Y = -16.14 + 0.706368X_1 + 0.176469X_2 + 0.076301X_3 + 0.022823X_4$;

II. $Y = -4.65 + 0.467868X_1 + 0.003437X_1X_2 + 0.001968X_1X_3 + 0.000316X_1X_4$;

III. $Y = 0.024423X_1^{1.723362} X_2^{0.174250} X_3^{0.036968} X_4^{0.025564}$;

IV. $Y = 2.88 + 0.733131X_1 - 3.912506X_2 + 0.034546X_3 + 0.342248X_2^2 - 0.000958X_3^2 + 0.020949X_2X_3$; and

V. $Y = 3.65 + 0.661496X_1 - 3.766318X_2 - 0.036684X_3 + 0.338716X_2^2 - 0.000957X_3^2 + 0.018642X_2X_3 + 0.001959X_1X_3$.

In the above functions Y refers to predicted total yield of grain sorghum per acre, X_1 refers to inches of soil moisture at seeding time, X_2 refers to inches of rainfall during the growing season, X_3 and X_4 refer to pounds of nitrogen and available phosphorus pentoxide (P_2O_5) per acre, respectively.[3]

On the basis of statistical tests reported in Table 2, equation V gives the most accurate predictions. However, scatter diagrams revealed that equation V overestimated the crop yields whenever the level of rainfall was 4 inches or less. In this situation equation III, a Cobb-Douglas function, described the crop response more accurately. Thus in the presentation which follows, equation V has been used to predict the yields of grain sorghum for situations with 6 or 8 inches of rainfall, and equation III has been used for yield predictions for situations with 2 and 4 inches of rainfall.

Predicted Yields for Grain Sorghum

Predicted or expected yields of grain sorghum obtained under different levels of soil moisture, rainfall and nitrogen application are reported

[3] It can be noted that some of the above equations omit phosphorus pentoxide(X_4). The preliminary statistical analysis, as well as the experimental data, showed that phosphorus did not give any significant yield increases. The sandy soil in southwestern Kansas appears to be high in available phosphorus but it does lack available nitrogen. For this reason there is no logical justification for including phosphorus pentoxide (P_2O_5) in the analysis.

TABLE 2. VALUES OF R, FOR DIFFERENT PRODUCTION FUNCTIONS AND VALUES OF t FOR INDIVIDUAL REGRESSION COEFFICIENTS (LISTED IN THE ORDER THEY APPEAR IN EQUATIONS WITH SIGNIFICANCE LEVELS IN PARENTHESES)

Production Function	Value of R	t values						
		b_1	b_2	b_3	b_4	b_5	b_6	b_7
I	0.7929	15.667 ($P<0.001$)	10.487 ($P<0.001$)	5.334 ($P<0.001$)	1.635 ($0.1<P<0.2$)			
II	0.7758	8.183 ($P<0.001$)	9.572 ($P<0.001$)	5.994 ($P<0.001$)	1.007 ($0.2<P<0.3$)			
III	0.7611	19.850 ($P<0.001$)	3.915 ($P<0.001$)	2.948 ($P<0.005$)	2.249 ($0.01<P<0.025$)			
IV	0.8316	18.275 ($P<0.001$)	6.431 ($P<0.001$)	0.647 ($0.5<P<0.6$)	8.532 ($P<0.001$)	1.747 ($0.05<P<0.1$)	4.776 ($P<0.001$)	
V	0.8927	10.536 ($P<0.001$)	6.118 ($P<0.001$)	0.511 ($0.6<P<0.7$)	8.439 ($P<0.001$)	1.746 ($0.05<P<0.1$)	4.010 ($P<0.001$)	1.482 ($0.1<P<0.2$)

TABLE 3. ESTIMATED OR PREDICTED YIELDS OF GRAIN SORGHUM PER ACRE FOR SPECIFIED SOIL MOISTURE, RAINFALL AND NITROGEN COMBINATIONS ON SANDY SOILS OF SOUTHWESTERN KANSAS

Depth of soil moisture[a] (inches)	Rainfall[b] (inches)	Pounds nitrogen per acre									
		0	10	20	30	40	50	60	70	80	90
24	2	6.6	7.2	7.4	7.5	7.6	7.6	7.7	7.7	7.7	7.7
24	4	7.4	8.1	8.3	8.4	8.5	8.6	8.7	8.7	8.7	8.7
24	6	9.3	10.3	11.2	11.9	12.5	12.8	13.0	13.0	12.8	12.4
24	8	11.2	12.6	13.9	15.0	15.9	16.7	17.2	17.6	17.7	17.7
36	2	13.2	14.4	14.8	15.0	15.2	15.3	15.4	15.5	15.6	15.7
36	4	15.0	16.3	16.7	17.0	17.2	17.3	17.4	17.5	17.6	17.7
36	6	17.2	18.4	19.6	20.6	21.4	22.0	22.4	22.6	22.6	22.4
36	8	19.2	20.8	22.3	23.6	24.8	25.8	26.6	27.1	27.5	27.7
48	2	21.8	23.7	24.3	24.7	24.9	25.1	25.3	25.5	25.6	25.7
48	4	24.6	26.7	27.4	27.8	28.1	28.4	28.6	28.7	28.9	29.0
48	6	25.1	26.7	28.0	29.2	30.2	31.1	31.7	32.2	32.4	32.5
48	8	27.1	28.9	30.7	32.3	33.7	34.9	35.9	36.7	37.4	37.8
60	2	32.0	34.8	35.7	36.2	36.6	36.9	37.2	37.4	37.6	37.7
60	4	36.1	39.3	40.3	40.9	41.3	41.7	42.0	42.4	42.4	42.6
60	8	35.1	37.1	39.1	40.9	42.6	44.0	45.2	46.3	47.2	47.8

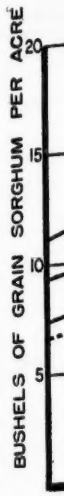
[a] At seeding time.
[b] During the growing season.

in Table 3. These yields were estimated from production functions or response curves and correspond to the data obtained from the experiment. Yields are predicted to start at 6.6 bushels per acre with 24 inches of soil moisture, 2 inches of rainfall and with no fertilizer. A yield of 47.8 bushels per acre is predicted at 60 inches of soil moisture, 8 inches of rainfall and at 90 pounds of nitrogen.

Graphic views of predicted grain sorghum response curves are provided in Figures 1-4. The height of each curve represents yield while the horizontal axis represents the amounts of nitrogen application. The response curves in Figures 1-4 were derived from the estimated yields reported in Table 3 and thus show estimated crop yields due to different amounts of nitrogen and to different soil moisture and rainfall conditions.

Statistical tests and the graphs (Figures 1-4) indicate that the best positive relationship among all the variables considered is that between the yields and the soil moisture at seeding time. Mathews and Barnes came to the same conclusion in their experiment.[4] An additional foot of soil moisture at seeding time at lower levels of moisture (24 and 36 inches) increases crop yields by 6.6 bushels. Higher yield increases from additional soil moisture were obtained at 48 inches and 60 inches of soil mois-

[4] O. R. Mathews and B. F. Barnes, Dryland Crops at the Dalhart, Texas, Field Station. U.S. Department of Agriculture, Cir. 564, 1940.



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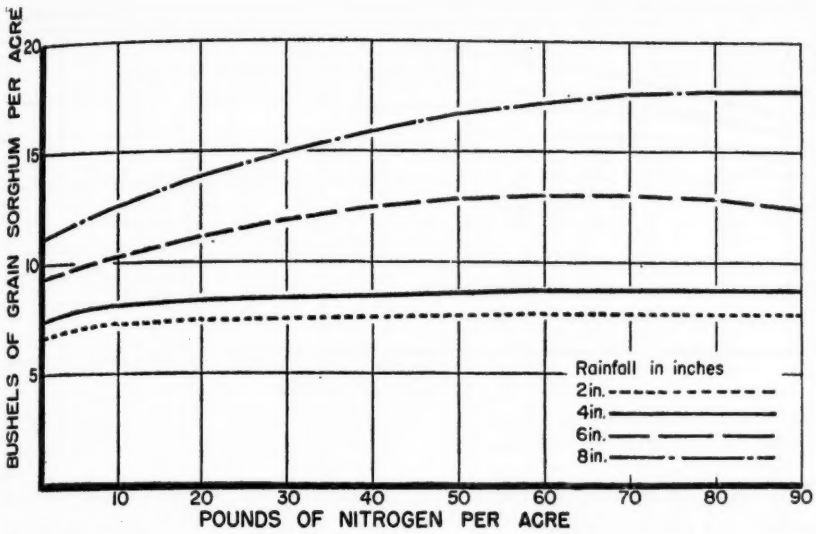

FIG. 1. GRAIN SORGHUM RESPONSE TO NITROGEN AND VARYING AMOUNTS OF RAINFALL DURING THE GROWING SEASON (DEPTH OF SOIL MOISTURE AT SEEDING TIME 24 INCHES).

ture. This relationship between the soil moisture at seeding time and the resulting yields is shown in Figure 5. The response curves in Figure 5 assume no nitrogen application (to avoid any possible interaction between the nitrogen and soil moisture). The crop response to soil moisture is that of increasing returns, particularly in situations where the amount of rainfall during the growing season is relatively low (2 to 4 inches). This means that each additional foot of soil moisture adds more to the total yield

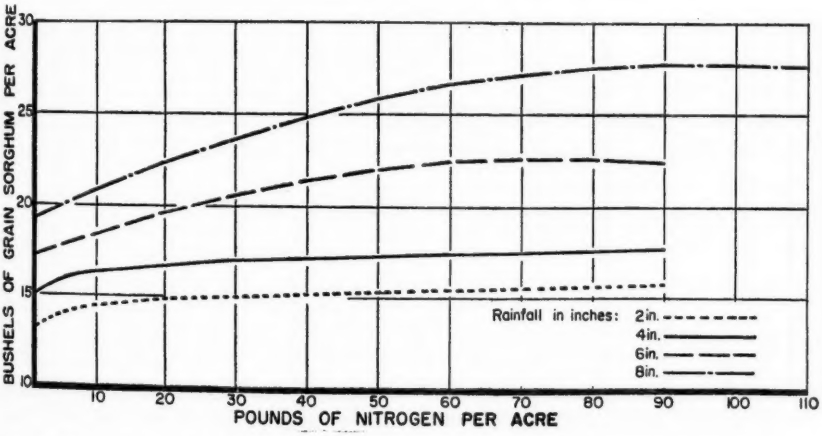

FIG. 2. GRAIN SORGHUM RESPONSE TO NITROGEN AND VARYING AMOUNTS OF RAINFALL DURING THE GROWING SEASON (DEPTH OF SOIL MOISTURE AT SEEDING TIME 36 INCHES).

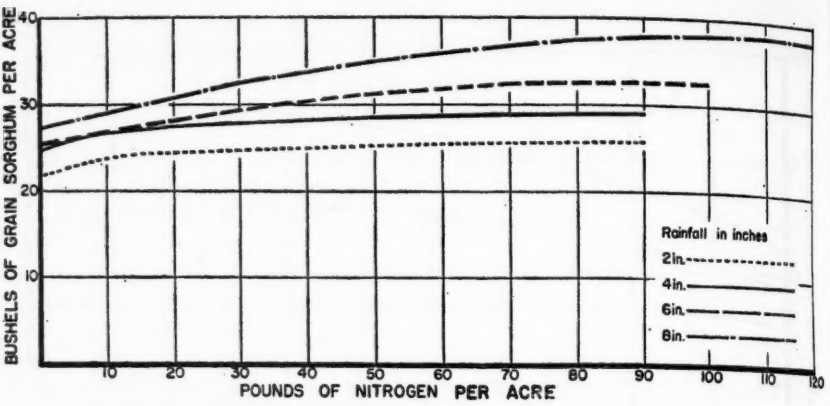

FIG. 3. GRAIN SORGHUM RESPONSE TO NITROGEN AND VARYING AMOUNTS OF RAINFALL DURING THE GROWING SEASON (DEPTH OF SOIL MOISTURE AT SEEDING TIME 48 INCHES).

than did the preceding foot. As the amount of rainfall increases to 8 inches, the crop-response-to-soil-moisture curve indicates constant returns. The question as to the range of increasing or constant returns to inches of soil moisture at seeding time was not answered by this experiment. Since the levels of soil moisture in this experiment did not exceed 60 inches, the yield estimates beyond the 60 inches soil moisture range would not be reliable. However, the data indicate yield increases due to soil moisture at seeding time are possible beyond the level of 60 inches.

The amount of rainfall during the growing season also affects the yields of grain sorghum. However its effects are not uniform. They depend also on the soil moisture conditions at planting time. The greater the depth of soil moisture at seeding time, the greater are the effects of rainfall on

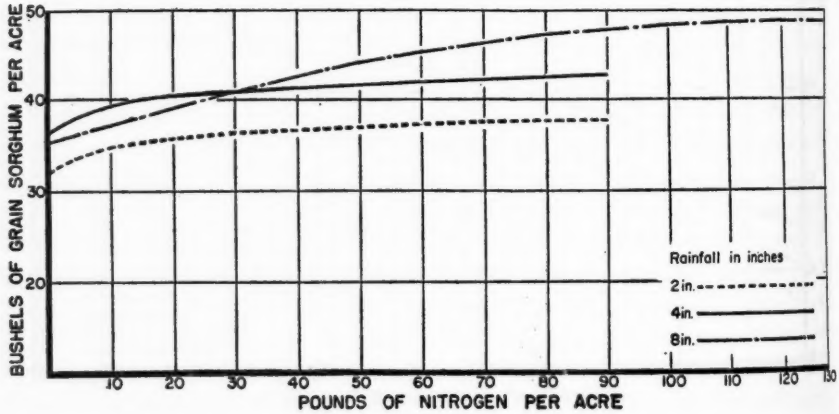

FIG. 4. GRAIN SORGHUM RESPONSE TO NITROGEN AND VARYING AMOUNTS OF RAINFALL DURING THE GROWING SEASON (DEPTH OF SOIL MOISTURE AT SEEDING TIME 60 INCHES).

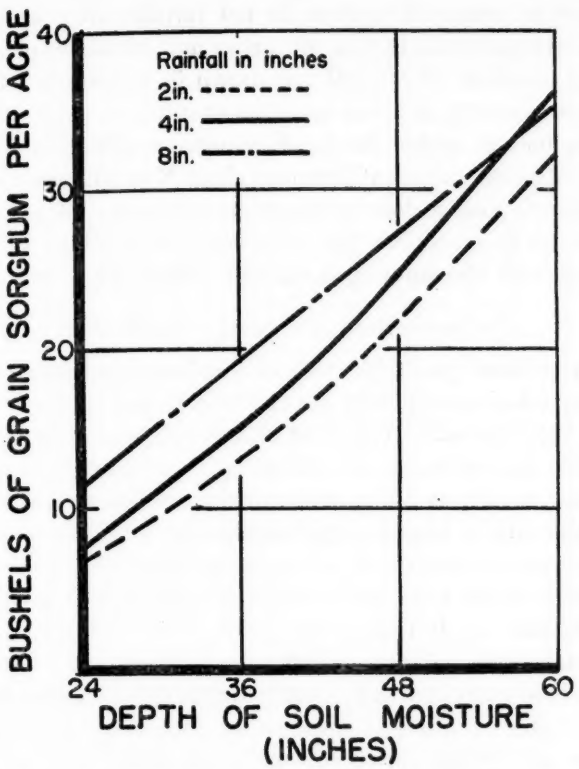

FIG. 5. GRAIN SORGHUM RESPONSE TO DEPTH OF SOIL MOISTURE AT SEEDING TIME AND VARYING AMOUNTS OF RAINFALL DURING THE GROWING SEASON

crop yields. For example, in the situation with no fertilizer and 24 inches of soil moisture, one inch of rainfall increases the per acre yield by 0.8 bushels as compared to more than 1.0 bushel per acre yield increase in the situations including 36 inches or more of soil moisture. This difference in the effects of rainfall on yields can be explained by the fact that plants started with smaller amounts of soil moisture experience a slower start, and thus rainfall during the growing season is not as effective as it is for plants having at the start more favorable moisture conditions. Also, rainfall during the growing season may come too late to benefit the crop. Similar observations can be made with respect to nitrogen and its effects on crop yields.

Figure 1 illustrates crop response to nitrogen where the depth of soil moisture at seeding time was 24 inches. A relatively low level of soil moisture coupled with a small amount of rainfall during the growing season gave little or no increase in yield due to nitrogen. The curves in Figure 1 (representing 2 and 4 inches of rainfall) appear flat and might explain

why farmers in semi-arid regions do not fertilize their crops. Crop responses to nitrogen at 36 inches, 48 inches and 60 inches of soil moisture and varying amounts of rainfall are shown in Figures 2-4, respectively. The response is strong at lower amounts of nitrogen application; it levels out and declines at higher levels of nitrogen application. The levelling out of crop response occurs at lower levels of N in situations representing less soil moisture than it does in situations with more soil moisture. Nitrogen interacts or is interdependent with both the depth of soil moisture at planting and with the amount of rainfall during the growing season.

Optimum Rate of Nitrogen Application

Optimum or most profitable rate of fertilizer application depends on the additions which result from use of fertilizer and on the fertilizer/crop price ratio. Since the effectiveness of nitrogen depends also on the level of soil moisture, the optimum rate of nitrogen application is not uniform. Soil moisture conditions along with nitrogen/grain sorghum price ratio determine the rate of nitrogen application that will, in a given situation, result in largest net returns. If soil moisture conditions are not favorable for the growth of the crop, no fertilizer will likely be applied regardless of how favorable the fertilizer/crop price ratio might be. On the other hand, adequate soil moisture conditions will likely make fertilizer application profitable even at less favorable fertilizer/crop price ratios.

Optimum rates of nitrogen application and resulting yields of grain sorghum per acre under varied soil moisture, rainfall and nitrogen/grain sorghum price situations are reported in Table 4. Optimum rates, shown in Table 4, were computed for 10 price situations, four levels of soil moisture at seeding time, and four levels of rainfall during the growing season, a total of 160 different combinations.

Nitrogen/grain sorghum price ratios vary from 0.025 to 0.250. The price ratio of 0.025 represents an extremely favorable nitrogen/grain sorghum price situation. This price ratio would result if grain sorghum were priced at \$4.00 per cwt. and nitrogen were priced at \$0.10 per pound or grain sorghum were priced at \$2.00 per cwt. and nitrogen at \$0.05 per pound. This price situation would be conducive to use of nitrogen even under relatively low soil moisture conditions. The optimum rate of nitrogen application would vary from 11.8 pounds of N per acre when the depth of soil moisture at seeding time is 24 inches and the expected rainfall during the growing season is 2 inches to 107.1 pounds of N per acre when the depth of soil moisture and the expected amount of rainfall are at 60 inches and 8 inches, respectively.

As grain sorghum becomes cheaper relative to nitrogen, the price ratio (P_N/P_S) increases and the use of nitrogen is less profitable. For example,

TABLE 4. OPTIMUM RATES OF NITROGEN APPLICATION AND RESULTING YIELDS OF GRAIN SORGHUM PER ACRE UNDER VARIOUS SOIL MOISTURE, RAINFALL AND NITROGEN/GRAIN SORGHUM PRICE SITUATIONS FOR SANDY SOILS OF SOUTHWESTERN KANSAS

Depth of soil moisture (inches)	Rainfall (inches)	Nitrogen/grain sorghum price ratios (P_N/P_S)																			
		0.025		0.050		0.0725		0.100		0.125		0.150		0.175		0.200		0.225		0.250	
		N	Sorghum	N	Sorghum	N	Sorghum	N	Sorghum	N	Sorghum	N	Sorghum	N	Sorghum	N	Sorghum	N	Sorghum	N	Sorghum
		Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.	Lbs.	Bu.
24	2	11.8	7.2	0	6.6	0	6.6	0	6.6	0	6.6	0	6.6	0	6.6	0	6.6	0	6.6	0	6.6
24	4	31.3	8.4	18.2	8.2	6.5	7.9	0	7.4	0	7.4	0	7.4	0	7.4	0	7.4	0	7.4	0	7.4
24	6	50.8	12.9	37.7	12.4	26.0	11.7	11.6	10.4	0	9.3	0	9.3	0	9.3	0	9.3	0	9.3	0	9.3
24	8	70.3	17.6	57.2	17.1	45.4	16.3	31.1	15.1	18.0	13.6	5.0	11.6	0	11.2	0	11.2	0	11.2	0	11.2
36	2	24.1	14.9	11.0	14.5	0	13.2	0	13.2	0	13.2	0	13.2	0	13.2	0	13.2	0	13.2	0	13.2
36	4	43.6	17.3	30.5	17.0	18.8	16.6	4.5	16.0	0	15.0	0	15.0	0	15.0	0	15.0	0	15.0	0	15.0
36	6	63.1	22.4	50.0	21.9	38.2	21.2	23.9	20.0	10.8	18.5	0	17.2	0	17.2	0	17.2	0	17.2	0	17.2
36	8	82.6	27.6	69.5	27.1	57.7	26.4	43.4	25.1	30.3	23.7	17.2	21.9	4.2	19.8	0	19.2	0	19.2	0	19.2
48	2	36.4	24.9	23.3	24.4	11.6	23.9	0	21.8	0	21.8	0	21.8	0	21.8	0	21.8	0	21.8	0	21.8
48	4	55.9	28.4	42.8	28.1	31.0	27.8	16.7	27.1	3.6	25.5	0	24.6	0	24.6	0	24.6	0	24.6	0	24.6
48	6	75.3	32.3	62.3	31.8	50.5	31.1	36.2	29.9	23.1	27.5	10.0	26.7	0	25.1	0	25.1	0	25.1	0	25.1
48	8	94.8	37.9	81.8	37.2	70.0	36.6	55.6	35.2	42.6	33.8	29.5	32.3	16.4	29.9	3.4	27.5	0	27.1	0	27.1
60	2	48.7	36.9	35.6	36.4	23.8	25.9	0.9	32.2	0	32.0	0	32.0	0	32.0	0	32.0	0	32.0	0	32.0
60	4	68.1	42.1	55.1	41.8	43.3	41.2	29.0	40.8	15.9	40.0	2.8	37.0	0	36.1	0	36.1	0	36.1	0	36.1
60	6	87.6	45.5	74.6	45.0	62.8	44.3	48.4	43.0	35.4	41.7	22.3	39.8	9.3	37.7	0	35.6	0	32.9	0	32.9
60	8	107.1	48.5	94.0	48.0	82.3	47.3	67.9	46.9	54.9	44.8	41.8	42.7	28.7	40.9	15.7	38.2	2.6	35.6	0	35.1

row 3 in Table 4 shows the optimum rates of nitrogen under varied price ratios and a given amount of soil moisture and rainfall (24 inches of soil moisture and 6 inches of rainfall). The most economic rate of N per acre at the 0.025 price ratio is 50.8 pounds; at 0.050 price ratio, 37.7 pounds; at 0.0725 price ratio, 26.0 pounds; at price ratio of 0.100 the optimum rate of nitrogen goes down to 11.6 pounds; and no amount of nitrogen is profitable at price ratios of 0.125 and higher.[5] The same comparisons can be made for other soil moisture, rainfall and price relationships shown in Table 4. These comparisons demonstrate the importance of considering price relationships as well as soil moisture conditions in determining optimum rates of nitrogen applications.

Summary and Conclusions

This study was designed to enable prediction of yields of grain sorghum under varied soil moisture, rainfall and fertilizer conditions on sandy soils in southwestern Kansas. It is based on experimental data compiled during the years 1951-1956.

All three factors, soil moisture at seeding time, rainfall during the growing season, and nitrogen are important in determining crop yields. Statistical tests indicate that the best positive relationship among the three factors considered in this particular set of circumstances is that between the yields and soil moisture at seeding time. The crop's response to soil moisture within the range considered (24-60 inches) indicates increasing returns. This evidence is particularly important for farmers who might have access to adequate water sources. In order to provide information on the moisture requirements for maximum growth of grain sorghum, additional experiments considering the depth of soil moisture of more than 60 inches are needed.

Rainfall, during the growing season, and nitrogen also affect the crop yields. However the effects are not uniform since they are dependent on soil moisture conditions at seeding time. The greater the depth of soil moisture at seeding time the greater are the effects of rainfall and nitrogen on yields. Grain sorghum response to phosphorus was found negligible even at higher levels of moisture.

The authors feel that experiments providing additional information with respect to soil moisture and its effects on yields, not only of sorghum but on other crops as well, can be a great assistance to farm operators. The depth of soil moisture can be determined with certainty before crops are planted, and thus it will reduce the uncertainty usually associated with anticipated crop yields. Soil moisture at seeding time gives relatively good estimates of expected crop yields apart of what the seasonal rainfall might be.

[5] On the basis of historic price relationships between nitrogen and grain sorghum, the relevant range of price ratios would be between 0.0725 and 0.100.

NOTES

FURTHER FACTS ON RAISING THE PRICE OF GOLD

HENRY A. WALLACE
Farvue Farm, South Salem, New York

Editor's note: Even as farmers have a long history of interest and concern with the nation's monetary policy, agricultural economists have followed money matters relating to prices and the state of business activity. One pioneer agricultural economist with such an interest was Dr. George F. Warren of Cornell University, an advocate of manipulating commodity prices by manipulating the price of gold.

Warren's activities in this field and related topics were the subject of an article, "Warren as Presidential Advisor," by F. A. Pearson, W. I. Myers and A. R. Gans appearing in *Farm Economics,* New York State College of Agriculture, Cornell University, Ithaca, December 1957.

There was another student of agriculture and monetary policy who was also in a position to offer advice to the President during this period. He is Henry A. Wallace, whose interpretation of ideas and events of the same period involves matters of no small historical significance and illustrates the meaning of political economy in decision making at the government program level.

FARM ECONOMICS for December of 1957 is devoted to the account of the importance of raising the price of gold in 1933 and the part played by Dr. George F. Warren in inducing President Roosevelt to increase gold prices from $20.67 an ounce to $35. Before presenting further data which should be made a part of the history and economic analysis of the period, I shall summarize briefly my interpretation of the viewpoint of Dr. Frank A. Pearson, appearing in that issue.

First: In 77 pages Pearson undertakes to prove that the economic recovery of 1933 was due almost solely to the increase in the price of gold.

Second: That the increase in the price of gold was due chiefly to Dr. George F. Warren.

Third: That Dr. Warren was fought in his beneficent efforts by the "Wallace crowd," the "Keynesian crowd," and the "Hopkins-tax-and-spend crowd." Warren's views, according to Pearson, were also opposed by such men as Herbert Hoover, Bernard Baruch, Ogden Mills, Lewis Douglas, Adolph Berle and Dean Acheson.

Fourth: A great mistake was made when the price of gold was set at $35 an ounce instead of $41.34 an ounce. "Warren's notes clearly indicated his repeated recommendations that the price of gold should have been doubled. In that event, the 1929 parity rate for crops and purchasing power of urban prices would have been restored."

Fifth: The way to increase prices and increase farm prosperity is to create the impression that gold prices will rise and then turn loose speculators in foreign exchange, securities and commodities.

Sixth: A Pearson chart demonstrates how the prices of gold, stocks and

commodities went up and down together in the spring and early summer of 1933.

Seventh: Pearson calls practically everyone who had any responsibility in Washington in 1933 an "Anti," meaning anti-Warren. He creates the impression that the last half of 1933 was full of intrigue like an 18th century court with "jangling nerves, frustration, back biting, hair pulling and name calling." He infers Warren was driven from Washington by the "Anti's."

Eighth: Pearson indicates that the various New Deal efforts aside from increasing the price of gold were harmful. He characterizes "Wallace's ever-normal granary" as being "camouflaged with ageless myrrh, frankincense, and Chanel No. 5."

Ninth: Some of the week by week gold price events from March 5, 1933, to January 31, 1934, are spelled out.

Now for comments on this presentation:

I agree with Pearson that the sharp and prospective reduction in the grains of gold in the dollar had a profound, inflationary effect. Insofar as the U.S. was competing for the international market for her exports, the increased price of gold gave this country's exports *temporarily* a great advantage. Momentarily, the prospect of further gold price increases was bound to dominate the speculative markets not only for gold but also for securities and commodities. But to claim that gold price increases would obviate the long-run necessity for profound nonmonetary adjustments to a postwar situation both domestically and internationally, is foolish. When the U.S. raised her tariffs a second time after World War I and then suddenly cut down on her loans abroad, while at the same time insisting on the repayment of governmental debts owing to us by France, Italy and England, it was inevitable that competitive currency devaluation would follow in an effort to lift the burden of debt by inflation. The monetary shot in the arm was probably necessary to save the lives of the patients, but that did not eliminate the eventual necessity for healthful food. When England went off gold in September of 1931 it became certain that the U.S. with her growing unemployment and rapidly declining price level would have to go too.

Having the greatest respect for Dr. George F. Warren, I nevertheless decline to give him the altogether dominant role assigned him by Pearson. My own interest in the Fisher Commodity dollar based on variable gold prices went back before World War I. In May of 1921 (possibly it was 1922) I was elected vice-president of the Stable Money Association. Irving Fisher was elected as the first president. Carl Snyder and Randolph Burgess were members and wanted to use the methods of Gov. Benjamin Strong of the New York Federal Reserve Bank to control the price level. These methods involved variations in the rediscount rate charged at the Federal Reserve Banks, buying or selling government securities, and

changes in the reserve requirements of the member banks. Fisher and I believed that these methods were good for ordinary stabilization purposes but that there might be conditions under which the price of gold should be varied. In the twenties and early thirties I gave talks at the Cornell Agricultural Short Courses several times and there got to know Dr. Warren. In those days the New York farmers had not been hit nearly as hard as the Iowa farmers. For a time some of them even thought that they were benefitting from cheap corn and oats from the Midwest for their milk cows and chickens. (If Pearson had lived in Iowa instead of New York he could not have referred as he did in the December 1957 *Farm Economics* to "the prosperous twenties to which most farmers and businesses had become fairly well adjusted.") It is not surprising that in my first talks with Warren I did not find him enthusiastic about the idea of increasing the price of gold to keep the price level from going down. But when the New York farmers were really hurt, Dr. Warren and F. A. Pearson did a magnificent job of compiling commodity price and gold statistics. At the same time I ran repeated articles in *Wallaces' Farmer* on the need for what I called the "Honest Dollar." Among the economists I found that the man most friendly to the idea of increasing gold prices was Prof. James Harvey Rogers of Yale whom I had met before his book *America Weighs Her Gold* came out in 1931. While I did not know it at the time, I found out later that Rogers was a relative by marriage to Secretary of Commerce Roper. Rogers and I met several times before I went to Washington as Secretary of Agriculture. Also prior to 1933 I met several times with members of the Committee for the Nation which had a keen interest in raising the price of gold. One of my Iowa associates developed the slogan, "Rock the U.S. off the gold standard." He sold the Iowa Bankers' Association on the idea. I tried to sell my associate farm paper editors on the need for government action to increase the price of gold.

When I got to Washington in 1933, one of the first things I did immediately before the inauguration was to see the just named Att. Gen. Homer Cummings on behalf of increased gold prices. I knew that under the Constitution it was the power of Congress "to coin money" and "regulate the value thereof." I had pointed out many times, especially after prices began to decline seriously, that I felt Congress was derelict in using its power to regulate the value of money. Obviously the new Attorney General as the advisor to the incoming Administration on Constitutional matters would be all important. Knowing nothing about Cummings' views in advance, I was enormously surprised to find that he had been a student of money and prices as far back as the time of Bryan. In brief, he did not wish to see the American farmer crucified on a cross of gold. Shortly after the inauguration I talked to Secretary of Commerce Roper. Roper was very friendly to the idea. At one of these meetings Professor Rogers

was present, but I am convinced that Roper would have been friendly to the idea even without the good offices of Rogers. I found Secretary of the Treasurey Woodin to be most polite but unwilling to go as far as Cummings and Roper. I had talked to Hull as a Senator in 1932 and had found him rather friendly to the idea at that time. But as Secretary of State I found him most cold and distant. (Today in 1958 I understand why any Secretary of State would abhor changing the price of gold.)

One of the strange allies I met at that time was Father Coughlin who happened to be in the apartment of an agricultural senator along with a Wall Street broker. The Silver Senators, the Greenbackers, and the "increase the price of gold" boys all joined forces eventually to put across Section III of the Agricultural Bill which was signed on May 12, 1933. In terms of immediate action, the significant item in Section III was that the President had the power to increase the price of gold from $20.67 an ounce up to $41.34 an ounce or to any spot in between.

Because I felt that increasing the price of gold was at that time one essential to agricultural recovery, I talked to Roosevelt in March and found that he had received much advice from both the Treasury and Justice departments. He was as sympathetic and open minded to the idea as Attorney General Cummings. But he felt he had to move a step at a time and it was obvious he wanted to keep the boys guessing. Completely abandoning the gold standard without giving huge windfall profits to speculators and without impinging on the powers of Congress, presented some grave legal problems and it was fortunate that Homer Cummings was genuinely sympathetic and cooperative. Roosevelt did not mention Warren to me, but I learned from Warren himself that he had seen the President on behalf of increased gold prices and had found the President sympathetic. With the Treasury mildly opposed to increasing the price of gold I have always felt that the Executive orders of March 6, April 5 and April 20 taking us off the gold standard step by step represented skilled work in the justice department. After April 20 when the speculators found which way the wind was blowing, they proceeded to overplay their hand. Amateurs went into the market expecting to make a killing.

On July 3 Roosevelt, who had been fishing for some days, invited the Cabinet to have lunch with him on board the *Indianapolis*. There he told with great glee how he had written two or three days before the message which had such a profound effect on the London Economic Conference. Roosevelt did not tell the Cabinet that Dr. Warren and Edward O'Neal of the American Farm Bureau Federation had really written the essence of the message, which for a time preserved the freedom of the U.S. to continue changing the grains of gold in the dollar. Of course the European statesmen were seriously disturbed. But Roosevelt was blithely unconcerned and felt that what he had done was best for the country. He

did not want his hands tied from abroad and was probably well-justified in taking Warren's and O'Neal's advice. One of the statements in this message read that "the U.S. seeks the kind of dollar which, a generation hence, will have the same purchasing and debt paying power as we hope to attain in the near future." Roosevelt liked this statement so well that he included it in a radio address on October 22, 1933, when he launched the RFC on a program of gold buying with prices to be fixed by the President and the Secretary of the Treasury. This time he said, "When we have restored the price level, we shall seek to establish and maintain a dollar which will not change its purchasing and debt-paying power during the succeeding generation." Seven months after his London Conference message, three months after his radio address on RFC gold purchase, Roosevelt fixed the price of gold at $35 an ounce where it is today. Query: Would Roosevelt, Warren and O'Neal have wanted the price of gold in 1958 reduced to less than $15 an ounce so that the price level could be brought down to where it was in January of 1934? In spite of the high sounding words, Roosevelt, Warren and O'Neal were really speaking for immediate results. Within a few days after July 3, gold prices, commodity prices, and securities shot up. Then within 10 days came the big smash. There were too many amateurs in the market. The speculators, whom Pearson so strongly admires are in the long run a slender reed on which to lean.

After the July 3 lunch with President Roosevelt on board the *Indianapolis*, I became convinced that it was essential to work out some regularized program for increasing the price of gold which would increase prices gradually without indefinitely disrupting the economies of foreign nations. Rogers had the same slant as Warren on the need for increasing gold prices and he had the advantage of being related to the Secretary of Commerce. Therefore I arranged with Roosevelt to see Warren, Rogers, Roper and myself. At this conference Roosevelt and Roper arranged for setting up a room in the Commerce building where Rogers and Warren could work on plans for increasing the price of gold. Referring to Rogers, Pearson says, "During Warren's absence, the Anti's had no doubt conferred and decided the President needed another adviser." To set Pearson's mind at rest, I may say that there was no conference of anyone except Roosevelt and myself. I was solely responsible for bringing in Rogers and setting up the July 10 meeting with Roosevelt. So far as I knew at that time, Rogers was just as much in favor of increasing the price of gold as Warren himself. I could see no reason why the two should not be completely compatible. I never knew that Warren and Rogers disagreed until I read Pearson's 1957 account. I still think Rogers was definitely in favor of increasing the price of gold. It would merely seem that Rogers felt that gold price increases by themselves would not in the

long run do the entire job. Rogers may have felt that in the long run, there must be some stimulus to put gold stocks to work aside from speculative and temporary enthusiasm for quick profits. Gold stocks in the treasury may be like coal in the basement. The coal does not heat the house till put to work in the furnace. Speculation in and of itself alone may have little more significance than warming a house by putting a match under the thermometer.

I was personally very fond of Warren. Never had I fought him or disagreed with him as Pearson suggests. I did not know that Warren was so strongly against the ever-normal granary as Pearson's account infers. If Warren had brought up this matter with me, I would have fought him. I did make it clear to Warren that I believed farmers had to have their legal, moral and economic equivalent of what union labor organization gave to labor and what corporate organization and tariff laws gave to business. I told Warren I did not think merely increasing the price of gold would long give to farmers the ability to adjust their production to a changed market overseas. I was all for increasing the price of gold as a temporary measure but I knew that Roosevelt could not indefinitely maintain the freedom of action of his July 3 position. Sooner or later out of fairness to countries whose commodities moved in world trade, we would, as the greatest nation in the world, have to stop the procedure of allowing a few men in the U.S. to rig the gold market. George Roberts in his National City Bank letter for November 1933 sized up the situation accurately when he said, "As soon, however, as the dollar stops falling, buyers are likely to dump their holdings."

Henry Morgenthau, Jr. became Secretary of the Treasury on January 1, 1934. As a loyal Cornellian and a disciple of Warren he knew that Warren wanted the price of gold set at $41.34, the full amount permitted by law. No doubt both Morgenthau and Warren had a strong influence on Roosevelt when in a message to Congress on January 15, 1934, he stated with regard to gold and the dollar: "Because of world uncertainties, I do not believe it desirable in the public interest that an exact value now be fixed." Here we have the Roosevelt and the Warren of July 3 speaking. In this same message Roosevelt also asked that Congress make it a matter of law that the price of gold should in no case be lower than $34.45 an ounce.

Why then with a brand new Secretary of the Treasury who was an extreme Warrenite did Roosevelt within two weeks go against his message to Congress and set the price at $35? If we are to believe Warren, as quoted by Pearson, the day following the signing of the RFC Gold Purchase bill, "Rogers stated the case for 55 [a 55 cent dollar or $37.58 for an ounce of gold]." With Warren, Rogers, and Morgenthau all for $37.58 for gold on January 31, 1934, why did the $35 price win out on

that day? My guess is that Warren's notes do not give the complete story and that the State Department working through the bankers and through Roosevelt himself won out with the $35 price and that the new Secretary of Treasury did not care to fight for the $41.34 price. Nor did Warren himself, according to his notes. His stand for $41.34 was theoretical. He was not willing to fight for it when fighting counted most on January 31, 1934.

According to Pearson's chart, the course of industrial stock prices in 1934 started going down rather sharply shortly after the price of gold was fixed on January 31, thus illustrating the George Roberts' thesis of the preceding November.

Warren had no use for the Reciprocal Trade program of Hull. He was essentially a high tariff man, whereas Secretary Hull, according to Pearson, believed that high tariffs were "the cause of all national ills and international chilblains."

I stood with both Hull and Warren. All through the twenties I had pointed out again and again that a creditor nation like the U.S. cannot indefinitely embrace a tariff program which causes more exports than imports. For many years loans and gifts may bridge the gap. Even before the Hawley-Smoot tariff bill was passed in 1930, I had predicted again and again that the big smash would come when we stopped loaning money abroad to furnish purchasing power for a volume of American exports greatly in excess of American imports. Warren seemed incapable of understanding this kind of reasoning just as Hull was incapable of understanding the Warren point of view. I was as strong as Warren for increasing the price of gold, but I agreed with Hull that this program could eventually create grave international embarrassment. Farmers always benefit more than other classes of society from the first year or two of inflation but they always suffer more when the joy ride comes to an end.

To indicate my reasoned attitude on gold and international trade, I quote from a letter I wrote President Roosevelt on April 25, 1940. At this time there had been strong opposition in Congress to continuing the President's power to raise the price of gold at his discretion from $35 to $41.34 an ounce. Also an effort was being made to stop the purchase of gold by the U.S. These same people were also against the extension of the Reciprocal Trade Agreement act as well as the extension of credit to foreign countries. This three pronged attack by narrow-minded nationalists, I said in my letter, was designed to "destroy a large part of our export trade. The great loss in foreign markets would in turn mean far-reaching adjustments in our productive plants, both industrial and agricultural. . . . Certainly I know the American farmer would prefer to see a world in which the products of his soil could be transformed increas-

ingly into world-wide distribution of food and clothing, and in which he, himself, could share in the benefits of increased industrial production. . . . It seems to me your most important immediate policy for enabling foreign powers to buy our goods is the gold purchase. . . . Such purchases have the advantage of serving as a bridge during the period in which the American public is being educated to the advantage of imports greatly in excess of exports, or the loaning of money in large quantities to those countries from which we must eventually be willing to accept greatly increased imports. Any cessation or hint of cessation of gold purchases would cause a world-wide panic, and would have such extreme effects on the British Empire that the Allies would lose the War." My five point conclusion in this letter follows:

1. "Continuation of the Reciprocal Trade Agreements program. . . . The 'have-not' countries should be assured of raw materials essential to their industries through trade arrangements rather than by a new division of colonies which would perpetuate and intensify the evils of the imperialistic system.
2. "Special world agreements to protect the producers and consumers of certain raw materials, such as cotton and wheat, which are chronically produced in surplus. . . . Some sort of International Evernormal Granary with each of the main exporting countries prepared to put a definite supply on the world market year after year for the ends of gradually increased consumption wherever needed for human welfare, would be needed to stabilize the prices and incomes of the primary world producers, and to give a greater stability to the world economy.
3. "The use of credit to facilitate international trade and reconstruction of the war-stricken countries. . . . All consideration of international credit must be accompanied by the willingness of the U.S. to accept goods and services. . . .
4. "Stabilization of currencies. . . .
5. "A reconsideration of the gold policy of the world, with a view to assisting the economic recovery of the various countries of the world, including our own."

At the finish of this 1940 letter I wrote to the President, "If the U.S. is going to be receiver for a bankrupt world, it is important that the party in power in the U.S. have some understanding of international conditions and some consistent program for our part."

On May 17, 1940, I presented a plan to the President which would "use about one-third of the gold of the Stabilization Fund as a catalyzer. I told the President we ought to stock-pile more raw materials and that we ought to have all the powers possible before Congress adjourned. . . .

I mentioned that we now had on hand 20,000 tons of rubber which we had obtained in exchange for 200,000 bales of cotton."

On February 10, 1943, according to my records, "I phoned Sumner Welles that I had been thinking about his proposition to return the U.S. to the old-fashioned gold exchange standard. I told him that if we did this it would be necessary to increase the volume by which our imports exceeded our exports by more than a billion dollars. Either we would have to increase our tourist travel annually by more than a billion dollars, or we would have to invest abroad each year more than a billion dollars in excess of what we otherwise would. I told Sumner that the figures I gave were merely illustrative but that the algebra of the situation was clear and we could fill in the arithmetic a little later."

Warren apparently felt that the ever-normal granary program was a competitor with the "higher gold price" solution of farm ailments. I looked on the two programs as both essential.

The ever-normal granary sensibly administered can be a great benefit to the eastern dairy and poultry farmer (in whose welfare I have a very direct interest). As long as I was Secretary of Agriculture the program called for loans at from 52 to 75 per cent of parity, depending on the supplies. The idea was that grain should flow out of the granary in years of bad weather so that the grain prices would remain relatively constant from year to year. In years of good weather the grain would flow into the granary. Again and again I said that if the supplies should become unmanageable, then we should start storing grain in the soil (soil bank). The Grange wanted to handle the surplus problem by the export debenture plan which meant that we would sell foreign customers their imported farm products at a lower price than our domestic consumers paid. Pearson's plan apparently would subsidize exports of surplus farm products by increasing gold prices. Query: Could this work any longer than there was uncertainty as to the future price of gold?

In going back over my notes made many years ago, I find this precise quotation concerning the Commodity Credit Corporation: "On November 11, 1933, I went to Des Moines to announce the corn loan, which was a turning point in the agricultural depression. The loan was made under the powers of the Commodity Credit Corporation. From a legal point of view it is one of the most powerful corporations ever set up under government. Jerome Frank set it up as a legal corporation with powers exceedingly broad, because the President had indicated he might require the corporation to buy gold. . . . What we had in mind was to set up a corporation for the purpose of making nonrecourse loans on wheat, corn, cotton and other commodities if needed, but especially commodities that were on the export market. I was figuring that by this mechanism I could set up the ever-normal granary. . . . It had long been an ideal with me to

accumulate crops in years of favorable weather and make them available in years of bad weather. . . . After the price break in July of 1933 the farm situation was desperate in spite of increasing the price of gold." (In mid October just prior to announcing the 45 cent corn loan, No. 3 corn prices at Iowa elevators had gone down to 20 cents a bushel.)

"I recognized the possibility of war coming, and I used to tell it to my associates at the time and mentioned it in an article in the magazine section of the *New York Times*, although not very strongly because I did not want to scare people. But it was very clear in my mind that it (the ever-normal granary) could be helpful if the world situation tightened up again." As I remember it today in 1958, President Roosevelt and I were talking in August of 1933 about the government making nonrecourse loans on cotton through an agency yet to be set up. Suddenly Roosevelt said, "Why should not a Commodity Credit Corporation set up to loan money on cotton also be used to buy gold?" It was because of this that the articles of incorporation of the Commodity Credit Corporation were so exceedingly broad. This corporation, which Pearson makes so sarcastically sweet smelling, has served the nation well in time of great stress and if handled sensibly can again serve as a source of strength, not embarrassment.

In my notes, I also find the following with regard to higher gold prices and the Export-Import Bank: "In thinking back over the gold revaluation, I can see why that led to the establishment of the Export-Import Bank, a bank that was always of great interest to me. I thought it was vital to establishing full employment on a world-wide basis. I can see why the Export-Import Bank resulted from the gold revaluation, because gold revaluation brought about very unstable currencies all over the world, especially in England and France. As a result of these unstable currencies, private capital would not invest in these foreign countries. There had to be some flow of American money to foreign countries if exports were not to disappear completely."

There are a myriad of adjustments which must be made during the 20 years after a great war. Monetary adjustments are the simplest but they are temporary even if very important in their effect. Neither the Keynesian approach, the low tariff approach, the foreign aid approach, the ever-normal granary approach, nor the Agricultural Adjustment approach can be completely laughed off if prices are rapidly falling and unemployment is rapidly rising in a world where friendly nations are in trouble. It is important that we keep the history of 1933 as straight as possible so that if we get into another time of great trouble we may act as wisely as possible. Strangely, there have been rumors abroad during the past six months that the U.S. was going to raise the price of gold which has remained fixed for 24 years.

A NOTE ON THE NERLOVE ESTIMATE OF SUPPLY ELASTICITY

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NERLOVE has proposed an ingenious method of estimating the response of acreage of a crop to the anticipated price for the crop.[1] Anticipated prices are not observable, but he hypothesizes that they change from year $t - 1$ to year t by some fraction of the difference between the actual and anticipated price in year $t - 1$:

$$P_t^* - P^*_{t-1} = \beta(P_{t-1} - P^*_{t-1}) \qquad 0 < \beta \leq 1 \tag{1}$$

P_t^* and P^*_{t-1} are anticipated prices, P_{t-1} is an actual market price, and β is a "coefficient of expectation."

Nerlove shows that (1) implies (2):

$$P_t^* = \beta P_{t-1} + (1 - \beta)\beta P_{t-2} + (1 - \beta)^2\beta P_{t-3} + \cdots \tag{2}$$

Acreage, x_t, is assumed to be a linear function of expected price and an error term, u_t (together with trend where appropriate):

$$x_t = a_0 + a_1 P_t^* + u_t \tag{3}$$

A supply elasticity coefficient can be computed from a_1. Equations (1) and (3) lead to

$$x_t = \pi_0 + \pi_1 P_{t-1} + \pi_2 x_{t-1} + v_t \tag{4}$$

π_2 equals $1 - \beta$, π_1 equals $a_1\beta$ and π_0 equals $a_0\beta$. All variables of (4) are observable. π_2 and π_1 can be statistically estimated, and they lead to an estimate of a_1. Using this approach, Nerlove computed supply elasticities for cotton, wheat and corn over the period 1909-32.

The approach assumes that acreage in any year represents the influence of past market prices, a smooth trend, and random factors. Intuitively, one

[1] Marc Nerlove, "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," *Journal of Farm Economics*, Vol. 38, May 1956, pp. 496-509. This note is also relevant to the supply and demand models presented by Nerlove in Vol. 40, May 1958, pp. 301-311, which appeared after the note was written.

may be uneasy about attributing all of the intercorrelation between acreages in successive years to prices. Suppose uneven technological development causes changes in acreage of a particular crop. Then acreages will be serially correlated, but not because of price. Moisture conditions affect wheat acreage in the Great Plains but are not independent in successive years. Boll weevil damage to cotton in the early 1920's may have affected cotton acreage in a nonrandom manner. Changes in money and opportunity costs often persist for more than one year. The influence of these and similar nonprice factors causing serial correlation of acreage frequently cannot be removed from the data by the calculation of trend. If such influences are present, they are likely to bias the estimates of β and a_1.

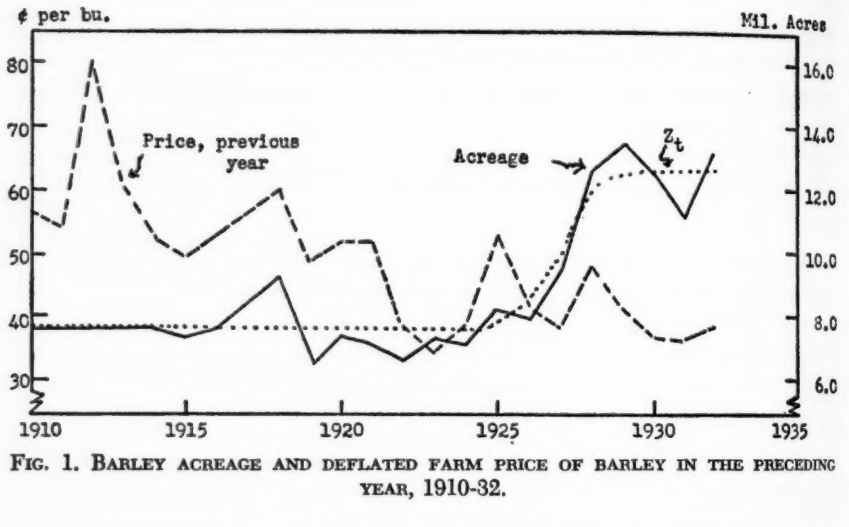

FIG. 1. BARLEY ACREAGE AND DEFLATED FARM PRICE OF BARLEY IN THE PRECEDING YEAR, 1910-32.

Barley acreage (Figure 1) illustrates the effect of a nonprice factor. Before the passage of the 18th amendment, the barbed beards of generally-grown varieties made farmers reluctant to handle barley and reduced its value as a livestock feed. But upon loss of the market for malt, "intensive research in various agricultural experiment stations resulted in the development of several new and improved varieties characterized chiefly by high yields and absence of the annoying barbed awns."[2] Acreage rose to a high plateau in the late 1920's.

When one makes computations like Nerlove's for barley, however, there is little indication that the results should be interpreted differently than

[2] Kenneth W. Meinken, *The Demand and Price Structure for Oats, Barley, and Sorghum Grains*, U. S. Department of Agriculture Tech. Bul. No. 1080, September 1953, p. 39.

those for cotton, wheat and corn (Table 1). All statistics seem reasonable, R^2 is high, and the Durbin-Watson test does not show the residuals v_t to be serially correlated. One might readily conclude that he had shown a high supply elasticity for barley, and he could easily rationalize on theoretical grounds a higher elasticity for a minor crop like barley than for a major crop like cotton, wheat or corn.

TABLE 1. SUPPLY ELASTICITIES COMPUTED BY NERLOVE'S METHOD FOR COTTON, WHEAT, CORN AND BARLEY, WITH RELATED STATISTICS, 1909–32

Item	Cotton[a]	Wheat[a]	Corn[a]	Barley[b]
Elasticity of supply	0.67	0.93	0.18	1.32[c]
Coefficient of expectation (β)	0.51	0.52	0.54	0.28
Trend	0.18	0.53	0.16	0.19[d]
R^2	0.74	0.77	0.35	0.80
Durbin-Watson statistic	2.34[e]	2.19[e]	2.04[e]	1.76[e]

[a] Taken from Nerlove, *op. cit.*, pp. 504 and 505.

[b] Based on $x_t = \pi_0 + \pi_1 P_{t-1} + \pi_2 x_{t-1} + \pi_3 T + v_t$ in which x is acreage harvested, P is the average July–October farm price of barley deflated by the average index of prices received by U. S. farmers during the same months, and T is time.

[c] Computed from a_1 and mean values of P_1^* and x_t.

[d] Ratio of annual trend increase in barley acreage (π_3) to average acreage during the period. Nerlove's article does not specifically define his "coefficient of trend."

[e] Insignificant serial correlation at the .05 level.

The Nature of the Bias

Barley provides an exaggerated example of deviations from the trend of acreage because of a nonprice influence, but probably serially correlated deviations of this sort are fairly common for crops. In general, equation (3′) would seem to be a better formulation than equation (3).

$$x_t = a_0 + a_1 P_t^* + Z_t + w_t \tag{3′}$$

Z_t is the influence of an important nonprice factor. For barley, it might be depicted by the dotted line in Figure 1 (though not there shown as deviations from its mean). w_t is assumed to be randomly distributed. u_t of (3) equals $Z_t + w_t$ of (3′).

Equation (4) then becomes (4′)

$$x_t = \pi_0 + \pi_1 P_{t-1} + \pi_2 x_{t-1} + Z_t + (\beta - 1) Z_{t-1} + w_t + (\beta - 1) w_{t-1} \tag{4′}$$

v_t of equation (4) equals the last four terms on the right of (4′).

$$v_t = Z_t + (\beta - 1) Z_{t-1} + w_t' \qquad (w_t' = w_t + (\beta - 1) w_{t-1}) \tag{5}$$

The autoregression of the Z's may be expressed as:

$$Z_t = c Z_{t-1} + z_t \tag{6}$$

c will be close to 1.0 when the Z's are nearly the same for large clusters of years. This will be so even if Z_t accounts for only a small part of the variation of x_t (though the amount of the bias discussed below may then be small). When the nonprice factor Z_t has little clustering effect, c will be close to zero.[3]

Substitution of (6) in (5) shows that Z_{t-1} has no influence on v_t in the special case $c = 1 - \beta$.[4] If $c > 1 - \beta$, v_t fluctuates directly with Z_{t-1} and hence with x_{t-1}. Accordingly, the estimate of π_2 will include some influence of the nonprice factor and will be biased upward. Since $\beta = 1 - \pi_2$, an upward bias in the estimate of π_2 will produce a downward bias in the estimate of β. This, in turn, will tend toward overstatement of a_1 and of the elasticity of supply.[5] The converse is true when $c < 1 - \beta$. Overestimation of supply elasticities, it should be noted, can result from high values of either c or β.[6]

It is not surprising, therefore, that the barley computations yield a comparatively low estimate of β and a high supply elasticity. The Durbin-Watson statistic, while mildly suggestive of positive correlation among the v_t, does not give warning of something amiss.

The conclusion seems warranted that the Nerlove supply elasticities may be significantly biased in important instances. This may happen because crop acreages often are serially correlated for reasons other than the common influence of a set of past prices. Discovery of and correction for the influence of nonprice factors are highly important for the method but may be difficult to accomplish. If the influence of nonprice factors is strong and the coefficient of expectation is high, the supply elasticities will be biased upward. When opposite conditions exist, the bias is downward, though the amount of bias introduced by a low value of c may be small.

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[3] In the barley case, $Z_t = 1.06\ Z_{t-1} + z_t$, and the z's are positively, serially correlated.

[4] Then $v_t = z_t + w_t'$. Though z_t usually will be positively correlated with z_{t-1} and w_t' is serially correlated, this need not bias the estimate of π_2.

[5] These generalizations are subject to a qualification arising from the fact that x_{t-1} and P_{t-1} can be expected to be negatively correlated. If the direction of bias is dominated by the relation between x_{t-1} and Z_{t-1}—which seems very likely—the generalizations hold.

[6] Nerlove pointed out (footnote 13, p. 503) that v_t will be serially uncorrelated only if $u_t = (1 - \beta)u_{t-1} + \varepsilon_t$, with ε_t randomly and independently distributed. He did not elaborate the relation of this to bias, however, only commenting, "To assume that this is so, is no worse an assumption than to assume no serial correlation among the u_t." In view of the probable importance of nonprice factors in causing serial correlation of acreages, one may agree with the statement but find little comfort in it.

ON THE NERLOVE ESTIMATE OF SUPPLY ELASTICITY: A REPLY

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BRANDOW has discussed one of my papers in the spirit of constructive criticism. His points are well-taken and I am in substantial agreement with him; I would, however, like to add to his comment. In doing so, I shall show that, while what he says is likely to be true, it may not be under all circumstances.

Bias Due to Specification Errors

In a recent paper in the *Journal of Farm Economics*, Zvi Griliches has adapted the work of H. Theil on specification errors to the analysis of specification bias in estimates of production functions.[1] The Theil-Griliches analysis applies directly to the problem which Brandow is discussing, and its use in this context leads to somewhat more rigorous conclusions than Brandow has presented.

Consider the general least-squares multiple regression problem

$$y = Xa + u, \tag{1}$$

where y is a column vector of the dependent variable over time, X is a matrix of the independent variables over time, u is a column vector of the randomly distributed residual terms over time, and a is a column vector of the "true" parameters of the relationship between the dependent variable and the independent variables. We assume that (1) is the "true" relationship which we should estimate, but for a variety of possible reasons we actually try to estimate

$$y = \overline{X}b + v. \tag{2}$$

In our problem the matrix $\overline{X}$ differs from X only by the omission of one or more columns and the vector b differs from a only by the omission of one or more rows. The simplicity of the difference here arises because the problem is to discover what effect the omission of a relevant variable, or relevant variables, has upon the estimates of the coefficients of the variables which are included.[2]

The question, in general terms, is: what is the relationship between the

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* On military leave.

[1] Zvi Griliches, "Specification Bias in Estimates of Production Functions," *Journal of Farm Economics*, Vol. 39, February 1957, pp. 8–20.

[2] Many other problems, such as errors in variables, etc., can also be discussed within the Theil-Griliches framework. It is to be hoped that this type of analysis will become a well-used tool of the agricultural economist.

estimates of b, $\hat{b}$, and the parameters of the true relationship, a? The answer which Griliches gives is that

$$E(\hat{b}) = P'a, \tag{3}$$

where $E(\hat{b})$ is the expected value of the least-squares estimates of the parameters in (2), a is a vector of the "true" parameters and P' is the transpose of the matrix P which is determined as follows: Take the auxiliary least-squares regressions of all the variables which should be included in the regression, $x_1, \cdots, x_n$, on the variables which are actually included, $x_1, \cdots, x_h$. These regressions are

$$x_i = p_{1i}x_1 + \cdots + p_{hi}x_h + w_i \quad (i = 1, \cdots, n). \tag{4}$$

The coefficients p_{ki} are the elements in the matrix P.

Specification Bias Under Expectational Models of Supply Response

Brandow has addressed his remarks to those of my results which are based on models of expectation formation. These results have an alternative interpretation.[3] This interpretation and specification bias under it are discussed in the following section.

According to Brandow, the "true" relation explaining acreage may involve a variable in addition to expected price which he denotes by z_t:

$$x_t = a_0 + a_1P_t^* + z_t + u_t, \tag{5}$$

where x_t=acreage, P_t^*=expected price, and u_t is a residual term. Transforming this by the method outlined in his paper and my earlier one, we have

$$x_t = a_0\beta + a_1\beta P_{t-1} + (1 - \beta)x_{t-1} + z_t - (1 - \beta)z_{t-1} + u_t - (1 - \beta)u_{t-1}, \tag{6}$$

where β is the coefficient of expectations. But suppose that we neglect the important variable z_t in (5). Instead, therefore, of estimating (6), the "true" relationship, we estimate

$$x_t = a_0\beta + a_1\beta P_{t-1} + (1 - \beta)x_{t-1} + v_t, \tag{7}$$

[3] See my "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," *Journal of Farm Economics*, Vol. 38, May 1956, footnote 12, pp. 502–503; and my *The Dynamics of Supply: Estimation of Farmers' Response to Price*, Chapters 2 and 9, Baltimore: The Johns Hopkins Press, 1958, in press. Since writing the above I have leaned more and more to this alternative interpretation. More complete discussions of it may be found in my "Distributed Lags and the Estimation of Long-Run Elasticities of Supply and Demand: Theoretical Considerations," *Journal of Farm Economics*, May 1958; and my *Distributed Lags and Demand Analysis for Agricultural and Other Commodities*, Agricultural Marketing Service, U. S. Department of Agriculture, 1958. Some of the reasons behind my change in emphasis may be found, on the demand side, in my "The Implications of Friedman's Permanent Income Hypothesis for Demand Analysis," *Agricultural Economics Research*, Vol. 10, January 1958, pp. 1–14; and on the supply side, in Appendix B of my unpublished paper with William Addison, "Statistical Estimation of Long-Run Elasticities of Supply and Demand," April 1958.

where v_t is actually

$$v_t = z_t - (1 - \beta)z_{t-1} + u_t - (1 - \beta)u_{t-1}.$$

what effect does this mistake have on our estimates of a_1 and β? That is, do we, as Brandow says, tend to underestimate β and overestimate a_1?[4] The answer unfortunately is not clear-cut.

First, note that *two* relevant variables, z_t and z_{t-1}, are omitted from (7). We can understand the effects of this omission by using the framework outlined in the preceding section. The auxiliary regressions of all the variables on the included ones are:

$$\begin{aligned} P_{t-1} &= p_{11}P_{t-1} + p_{21}x_{t-1} + w_1 = P_{t-1} \\ x_{t-1} &= p_{12}P_{t-1} + p_{22}x_{t-1} + w_2 = x_{t-1} \\ z_t &= p_{13}P_{t-1} + p_{23}x_{t-1} + w_3 \\ z_{t-1} &= p_{14}P_{t-1} + p_{24}x_{t-1} + w_4 \end{aligned} \tag{8}$$

Note that the first two auxiliary regressions are the identities, $P_{t-1}=P_{t-1}$ and $x_{t-1}=x_{t-1}$, so that $p_{11}=p_{22}=1$ and $p_{21}=p_{12}=0$.

It follows from equation (3) above that

$$E\begin{pmatrix} \widehat{a_1\beta} \\ (1 - \hat{\beta}) \end{pmatrix} = \begin{pmatrix} 1 & 0 & p_{13} & p_{14} \\ 0 & 1 & p_{23} & p_{24} \end{pmatrix} \begin{pmatrix} a_1\beta \\ 1 - \beta \\ 1 \\ -(1 - \beta) \end{pmatrix}, \tag{9}$$

where $\widehat{a_1\beta}$ is the least-squares estimate of the coefficient of lagged price in (7) and $(1-\hat{\beta})$ is the least-squares estimate of the coefficient of lagged acreage in (7). Expanding (9) we have

$$E(\widehat{a_1\beta}) = a_1\beta + p_{13} - p_{14}(1 - \beta), \tag{10}$$

and

$$E(1 - \hat{\beta}) = (1 - \beta) + p_{23} - p_{24}(1 - \beta). \tag{11}$$

Thus, the bias in our estimate of $a_1\beta$ is given by

$$E(\widehat{a_1\beta}) - a_1\beta = p_{13} - p_{14}(1 - \beta), \tag{12}$$

and the bias in our estimate of $\hat{\beta}$ is given by

$$E(\hat{\beta}) - \beta = -p_{23} + p_{24}(1 - \beta). \tag{13}$$

The coefficients p_{13}, p_{14}, p_{23} and p_{24}, show the relation between the excluded variables, z_t and z_{t-1}, and the included variables, P_{t-1} and x_{t-1}.

[4] In answering this question we neglect the possibility that $u_t-(1-\beta)u_{t-1}$ may be serially correlated. There are reasons why this should not be, but these are closely connected with the alternative interpretation. See footnote 6.

The variable z_t which Brandow has chosen for barley is the shift between varieties of barley. It is positively correlated with both x_t and x_{t-1} and, since x_{t-1} is probably negatively correlated with P_{t-1}, z_t and z_{t-1} are probably negatively correlated with P_{t-1}. Thus it is reasonable to assume that

$$\begin{cases} p_{13},\ p_{14} < 0 \\ p_{23},\ p_{24} > 0 \end{cases} \tag{14}$$

Since p_{23} and p_{24} are likely to be of about the same magnitude and since $0<\beta\leq 1$, it is likely, by (13), that

$$E(\hat{\beta}) < \beta, \tag{15}$$

that is, that the coefficient of expectations is underestimated when the relevant variable z_t is omitted. This is also Brandow's conclusion, but his further conclusion that the coefficient of lagged price in the supply relation (5), a_1, is overestimated does not follow.

Since p_{13} and p_{14} are likely to be negative, and since $0<\beta\leq 1$, it follows that if p_{13} and p_{14} are of roughly the same magnitude,

$$E(\widehat{a_1\beta}) < a_1\beta, \tag{16}$$

that is, we underestimate the coefficient of lagged price in (7). Now the estimate of a_1, $\hat{a}_1$, is obtained by dividing $\widehat{a_1\beta}$ by the estimate of β, $\hat{\beta}$; hence, we may either over- or underestimate the elasticity of supply with respect to expected price depending on the relative magnitudes of the bias in $\widehat{a_1\beta}$ and $\hat{\beta}$. To be sure, if the relation between z_t, z_{t-1} and P_{t-1} is weak compared with the relation between z_t, z_{t-1}, and x_{t-1}, it is plausible that the elasticity of supply will be overestimated, as Brandow indicates, but it is by no means certain that it will be.

Specification Bias Under Adjustment Models of Supply Response

As indicated above, the results which Brandow discusses are open to an alternative interpretation. The effect of specification errors on the coefficients of the supply relationship is similar but not identical to that discussed in the preceding section. Since the alternative interpretation has been discussed at some length elsewhere, only a brief sketch of it will be given.[5]

Suppose that farmers base their long-run production plans on lagged price but that they do not fully adjust to changed conditions within one year. Let $\bar{x}_t$ be long-run equilibrium acreage, P_{t-1} last year's price, and z_t some other variable affecting supply, then the long-run supply relationship may be written

$$\bar{x}_t = a_0 + a_1 P_{t-1} + z_t + u_t. \tag{17}$$

[5] See the references cited in footnote 3.

We assume with Brandow that the coefficient of z_t is unity. $\bar{x}_t$ cannot, of course, be observed. We suppose that the relation between current acreage, x_t, and long-run equilibrium acreage, $\bar{x}_t$, is given by the difference equation

$$x_t - x_{t-1} = \gamma[\bar{x}_t - x_{t-1}], \quad 0 < \gamma \leq 1, \tag{18}$$

where γ is a constant called the coefficient of adjustment. Substitution of (17) in (18) yields

$$x_t = a_0\gamma + a_1\gamma P_{t-1} + (1 - \gamma)x_{t-1} + \gamma z_t + \gamma u_t, \tag{19}$$

which is the "true" relationship we should estimate.[6] Instead, we omit z_t and estimate

$$x_t = a_0\gamma + a_1\gamma P_{t-1} + (1 - \gamma)x_{t-1} + v_t, \tag{20}$$

where

$$v_t = \gamma z_t + \gamma u_t.$$

Note that (19) differs from (6) in the omission of z_{t-1} but that (20) contains exactly the same variables as (7).[7]

The appropriate auxiliary regressions are

$$\begin{cases} P_{t-1} = p_{11}P_{t-1} + p_{21}x_{t-1} + w_1 = P_{t-1} \\ x_{t-1} = p_{12}P_{t-1} + p_{22}x_{t-1} + w_2 = x_{t-1} \\ z_t = p_{13}P_{t-1} + p_{23}x_{t-1} + w_3. \end{cases} \tag{21}$$

By a similar analysis to that employed above, we have

$$E(\widehat{a_1\gamma}) - a_1\gamma = p_{13}\gamma \tag{22}$$

and

$$E(\hat{\gamma}) - \gamma = -p_{23}\gamma. \tag{23}$$

In the previous section in which expectational models were discussed, it was necessary to assume something about the relative magnitudes of the coefficients in the relations between z_t and z_{t-1} and P_{t-1} and x_{t-1}. In the present example, however, such assumptions are not necessary and the conclusions are correspondingly more clear-cut. If z_t is positively related to x_{t-1} and negatively related to P_{t-1}, p_{13} is negative and p_{23} is positive. Since γ is positive, it follows that the omission of z_t in (20) leads to a down-

[6] Note that this equation shows why serial correlation is often found in the calculated residuals of regressions which are not based on dynamic models. If the regression is not based on a dynamic model, x_{t-1} is omitted from (19). Since (19) suggests that x_t and x_{t-1} are serially correlated, so will be the residual $(1-\gamma)x_{t-1}+\gamma u_t$. But if u_t is not serially correlated, γu_t will not be either. For a fuller explanation, see section 5 of the final reference cited in footnote 3.

[7] This fact suggests a way to distinguish between the appropriateness of expectational versus adjustment models of supply. See the second and fourth references cited in footnote 3.

ward bias in both the estimate of the coefficient of adjustment, $\hat{\gamma}$, and the estimate of the product of the slope of the long-run supply function with the coefficient of adjustment, $a_1\hat{\gamma}$. Consequently, though it is certain that we underestimate the coefficient of adjustment by omitting z_t, it is not certain that the long-run elasticity of supply will be underestimated.

Conclusions

Brandow has performed a valuable service in pointing out the sensitivity of estimates of the coefficient of expectations or adjustment to the omission of relevant variables. He found that the omission of a variable which is positively correlated with acreage tends to bias the estimate of the coefficient of expectations downwards. Use of the Theil-Griliches analysis of specification bias substantiates Brandow's conclusion and a similar one for an alternative approach to supply analysis. Brandow's conclusion is more clearly substantiated with respect to the alternative interpretation of my results than the one which he actually analyzed. The analysis shows, however, that his conclusion that the estimated elasticity of supply is biased in an upward direction, does not follow from his assumptions.

The type of nonprice variable which Brandow has introduced in connection with his investigation of supply response in the production of barley is an extremely important type. Factors such as he has considered should be considered in further investigations of supply response, especially in those circumstances in which the coefficients of expectation or adjustment are found to be unreasonably low.

LONGEVITY AND STABILITY OF MEMBERSHIP IN FARM MANAGEMENT ASSOCIATIONS

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IN FIVE Midwestern states, farm management associations have served as a source of data for both extension and research in farm management.[1] The value of the records of these associations for research depends on the accuracy of the records, the representativeness of the sample, and especially on the longevity and stability of membership. This note will deal largely with this latter consideration.

[1] Farm management associations were initiated in Illinois in 1925, in Minnesota in 1928, in Iowa and Kansas in 1931 and in Wisconsin in 1946. In the three last named states they have been primarily an extension activity, but in both Illinois and Minnesota the records of these associations have been used extensively as a source of data for farm management research analysis. For additional information on the use of farm records in farm management research the reader is referred to a publication by the senior author of this article, "Farm Accounts as a Source of Data for Farm Management Research," Minnesota Technical Bulletin 219, February 1956.

Two farm business associations are in operation in Minnesota—one in a dairy farming area in southeastern Minnesota since 1928 and one in a corn and meat producing area in southwestern Minnesota since 1940. The farms in both groups are fairly representative of the area in type and organization though somewhat larger in size. The size of farms in the Southeast Association has increased during the 30 years, partly as the result of dropping the smaller farms and adding larger ones, but much more by adding additional acres to existing farms. This is a common trend in the area. In the Southwest Association there has been little change in farm size either within the Association or in the general area. The quality of management on these Association farms is somewhat higher than the average of the area but still varies widely among the farms included.

One of the important functions of these Associations is to present a picture of current changes in farm organization and farm techniques as well as changes in farm earnings. The records serve as a barometer to register changes in farm organization, farm practices, farm efficiency, and farm earnings in the area from year to year. To do this effectively the farms included should be not only reasonably representative of the area in type but the group must be reasonably stable in composition from year to year. Twenty-three per cent of all members enrolling in these associations dropped out at the end of the first year and by the end of five years more than two-thirds of those enrolled had withdrawn (see Table 1). From the fifth year on, the rate of dropouts turns down sharply and the make-up of the group becomes quite stable. A few will withdraw because of age, ill health, or moving to another area. With this stability also comes more interest in the records and more emphasis on accuracy and completeness.

The data in Table 2 bring out some interesting facts about the present

TABLE NO. 1. PERCENTAGE DISTRIBUTION OF YEARS OF MEMBERSHIP IN MINNESOTA FARM MANAGEMENT ASSOCIATIONS BY ALL MEMBERS ENROLLED SINCE ASSOCIATION WAS ORGANIZED

	Southeast Association	Southwest Association
Years in Operation	30.0	18.0
Total number of members	762.0	544.0
Average years of records per member	6.1	5.2
Membership by 5 year periods		
1– 5 years	67.4	69.7
6–10 years	11.9	16.1
11–15 years	7.2	8.3
16–20 years	6.7	5.9*
21–25 years	3.5	—
26–30 years	3.3	—
	100.0	100.0

* Southwest Association in operation only 18 years.

membership of the two associations in 1957 after they had achieved a considerable degree of stability. It is interesting to note that in the Southeast Association 10 per cent of the farms starting in 1928 were still included in the 1957 membership. In most cases the acreage per farm had increased in line with the general trend in farm size in the area but perhaps at a more rapid rate, since the operators who remained in the Asso-

TABLE 2. MEMBERSHIP OF SOUTHEASTERN AND SOUTHWESTERN FARM MANAGEMENT ASSOCIATIONS IN 1957

	Southeast Association	Southwest Association
Years of operation	30.0	18.0
Number of members initial year*	124.0	165.0
Number of members in 1957	162.0	162.0
Percentage of farms in 1957 included in the Association in the initial year	10.0%	12.0%
Number members in Association—entire period	6.0	19.0
Average years in Association	15.0	9.0
Percentage distribution of 1957 members by years of membership in Association		
One year	5.0	6.2
One to six years	20.4	43.8
Seven to 12 years	16.7	21.0
13 to 18 years	32.7	35.2
19 to 24 years	14.8	—
25 to 30 years	15.4	—

* 1928 for Southeast Association and 1940 for Southwest Association.

ciation were perhaps somewhat more alert in keeping their business adjusted in line with current trends. In some of these cases the farm had passed from a father to a son, or a son or a son-in-law had been taken in as a partner.

Only six of the farms enrolled in the Southeast Association in 1928 remained in the Association through each of the 30 years, and on two of these the original operator had been succeeded by his son. In the Southwest Association 12 per cent of the members enrolled in 1940 were still keeping records in 1957, but only 19 had kept records each of 18 years.

It is significant that the average years that the individual members had been enrolled in each of the two Associations was exactly one-half of the entire period of years that the Association had been in operation. The longer these Associations continue in operation, the greater the average number of years of record keeping for the individual members. Apparently both of these Associations have become fairly stabilized and annual replacements are only 5 or 6 per cent of the total enrollment. Retirement and moving from the area account for most of the turnover after the first few years.

This increasing stability of the composition of these Associations over

the years materially enhances the value and range of their use for research purposes. The membership constitutes a "captive clientele" of capable responsible farmers to whom the researcher may turn at any time for information on the farmer's attitude or response to current developments in agricultural technique, agriculture policy, and other factors that affect the economic status and welfare of farmers. It enables him to keep his finger on the pulse of a group of representative farmers and record their reactions and response to current changes.

The authors have found members of these Associations highly cooperative in supplying special information from time to time in addition to that recorded regularly. For example, by supplementing the usual financial, feed, and production records of the association with labor records and other supplementary information, it is possible to get labor input data and compute production costs for specific commodities and enterprises.[2] Association members volunteered to supply this additional information because it made possible a more detailed analysis of each individual's business. During the past two years, detailed labor reports on milking herds and on lots of feeder cattle covering one week each month have provided information on labor inputs by size of unit, types of equipment used, and by production practices followed.[3] The findings are not only useful to the individuals concerned but are valuable for research and extension purposes also.

A study of the personal factors that affect a farmer's financial success was made during the first five years of the operation of the Southeast Minnesota Farm Management Association.[4] Though a pioneer study in the field, it not only commanded the interest and cooperation of the members but produced results that were far more valuable since the Association records served as a background of information on the members' earnings and their general operations.

Recently a study was made of the changes made in farm organization practices by the Southeast Association members who had 25 years or more of membership.[5] This study brought out some important facts as to how age and financial status conditions the farmer's operations.

Members of the two Associations in southern Minnesota cooperated

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[2] Rorholm, N., Engene, S. A., Pond, G. A., and Hinton, R. A., "Farm Labor and Farm Costs, 1951, 1952, and 1953." *Minnesota Agricultural Economic Reports 199, 208, and 217.*

[3] Aune, H. J., and Day, L. M., "Labor Requirements for Dairy Cattle as Related to Herd Size," *Minnesota Farm Business Notes,* No. 392, February, 1958.

[4] Wilcox, W. W., Boss, A., and Pond, G. A., *Relation of Variations in the Human Factor to Financial Returns in Farming,* Minnesota Agr. Exp. Sta. Bul. 288, June, 1932.

[5] Moore, D. S., " A Study of Individual Motivation and of Farm Business–Household Relationships Upon the Organization of 29 Southeastern Minnesota Farms," 1928-1955. Ph.D. Thesis, Univ. of Minnesota, July, 1957.

in a study of the corn allotment program when first initiated. They reported their response and their general reaction to it.[6] In a study of beginning farmers and their problems, Association members responded generously to a questionnaire regarding their own start in farming and their general appraisal of the problems of beginning farmers.[7]

The function of a farm business association as a group of representative, progressive farmers interested in improving their business and with established friendly cooperative relationships with the research and extension staff in farm management is a factor far more important than generally realized. These farmers are available for contact and cooperation at any time. Their response is generally prompt and enthusiastic. They are eager for new information and willing to do their part in providing it. Not only can the information be obtained from them quickly and with more accuracy than from a random group of farmers, but it can be secured at a minimum of cost.

The research and extension workers, knowing the members of these associations personally as they do, can make fuller and more effective use of both the regular records and any special information secured than they can of data from any other farmers with whom they had less contact and knowledge. However, it must be emphasized that the value of farm business associations is greatly increased as the years covered by them increase as well as by the length of time the research and extension personnel using the records have been in contact with the associations and their members. A stable research and extension staff working with the members of an association is as important in making the most effective use of the records as is stability of membership within the Association.

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[6] Pond, G. A. and Moore, D. S., "Farmers' Reaction to the Corn Allotment Program Other Farm Programs," *Minnesota Agricultural Economics Report 218*, November, 1954.

[7] Pond, G. A., Swanson, H. W., and Cavert, W. L., *Starting Farming Today–Can it be Done? What Does it Take?* Minnesota Agr. Exp. Sta. Bul., 428. April 1955.

USE OF NORMAL-CURVE THEORY IN CROP INSURANCE RATEMAKING*

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UNDER the federal crop insurance program, the coverage for the acreage planted serves as a guarantee to the insured farmer. He is paid the difference between this coverage in dollars and the value of his production, usually based on a predetermined price per unit. The amount of coverage per acre is usually established by areas that are relatively homogeneous, and all land planted in that area takes the same coverage. Within a county, the classification of land by areas for coverage purposes is based on the productivity of the land. However, it is the annual deviations below the normal productivity (in fact, below the coverage, which is considerably lower) that result in indemnities for loss.

As the insurance contract is with the individual farmer, the reduction in yield on his farm only determines his indemnity. So for estimating possible indemnity payments for actuarial purposes, the best data are actual annual yields on individual farms. But annual yield data of this kind are scarce, especially for a series of years. Government agencies in many countries have annual yield data for political or other subdivisions. In the United States, county yields per planted acre are available for some crops for 30 years or more. The problem is how to use these aggregate data to estimate probable losses under plans of insurance that provide payment for loss when individual farm yields, not aggregate yields, fall below some level of coverage or guarantee.

Earlier methods used by the Federal Crop Insurance Corporation (FCIC) involved computation of losses for a short period from sample data for individual farms. These loss data were then extended to cover a longer period by using annual county yields for a longer period. For this, certain curves of relationship were used. Later, a method that utilized normal-curve theory was developed. It is used when county yields are available but when little is known as to the distribution of farm yields around their average, the county yield. So far as the author knows, nothing has yet been recorded as to the derivation of the FCIC formula.

This presentation has as its purpose (1) the derivation of the FCIC formula and the presentation of an example of its use, and (2) the derivation and application of a formula recently suggested for use in connection with a proposed experimental program on paddy (rice) in six districts of Ceylon.

Definitions of the symbols used are:

* Thanks are due to William H. Rowe, Federal Crop Insurance Corporation, for helpful suggestions.

SYMBOLS USED

Symbol	FCIC	Ceylon
$\bar{Y}$	Long-term, area-average yield	Long-term, area-average yield or 1/N multiplied by ΣY_i
p	Fixed price per unit at which production is valued	Same
L	Average annual loss cost or pure-premium rate per acre (in commodity units)	Same
C	Coverage per acre (in commodity units)	Same
	Equal to $0.6\bar{Y}$	Equal to $0.5\bar{Y}$
y_i	Yield on a particular acre in year for which rate calculation is made	
Y	Mean of acre yields y_i for particular year. Area annual yield or 1/N multiplied by Σy_i	Area (district) annual yield for particular year
n	Number of acres (in particular year) with $y_i < C$	Number of years in which area annual yields $Y_i < 0.7\bar{Y}$
N	Total acreage used in computing area yield Y for particular year	Total number of years in history period
R	Mean yield per acre on indemnified acres for particular year	Mean yield for indemnity years, i.e., area-average yield for years when $Y < 0.7\bar{Y}$
σ	Standard deviation of acre yields y_i about area yield Y for particular year. Equal to $0.25\bar{Y}$	Standard deviation of area annual yields Y_i about $\bar{Y}$
d	Height of ordinate at C	Height of ordinate at $0.7\bar{Y}$
A	Proportion of total acres with yields $y_i < C$ in a particular year. $A = n/N$	Proportion of N years having yields $Y_i < 0.7\bar{Y}$. $A = n/N$

Figure 1 shows a distribution of acre yields y_i about the area yield Y for a particular year. Here y_i = yield on a particular acre this year ($y_i < C$). From here on, the definition of this symbol is limited to a yield that is less than the coverage C.

The total indemnity payable this year is $\Sigma(C - y_i)$ and the average annual loss cost is $\frac{1}{N}(nC - \Sigma y_i)$. But since $R = \frac{1}{n}\Sigma y_i$, then $\Sigma y_i = nR$. Therefore, $nC - \Sigma y_i = nC - nR = n(C - R)$, and the average annual loss cost or pure-premium rate for this year is $\frac{n(C-R)}{N}$, which equals $A(C-R)$ or $AC - AR$. Therefore

$$L = AC - AR \tag{1}$$

It can be demonstrated that the average value R of a truncated normal distribution is:

$$R = Y - \frac{d\sigma}{A} \tag{2}$$

where d is the height of the ordinate at C.[1]

Substituting in (1)

$$L = AC - AY + d\sigma \quad \text{from which}$$

$$L = A(C - Y) + d\sigma \tag{3}$$

Formula (3) is the FCIC formula.

Example

$Y = 7.7$ bushels $\qquad C = 0.6\overline{Y} = 6.9$ bushels

$\overline{Y} = 11.5$ bushels $\qquad \sigma = 0.25\overline{Y} = 2.875$ bushels

$$\frac{Y - C}{\sigma} = \frac{0.8}{2.875} = 0.28 \quad \text{so} \quad Y - C = 0.28\sigma$$

At 0.28σ (from normal-curve data)

Area between C and Y = 0.1103

Ordinate at C = d = 0.3836

So area A (left of C) = 0.5000 − 0.1103 = 0.3897

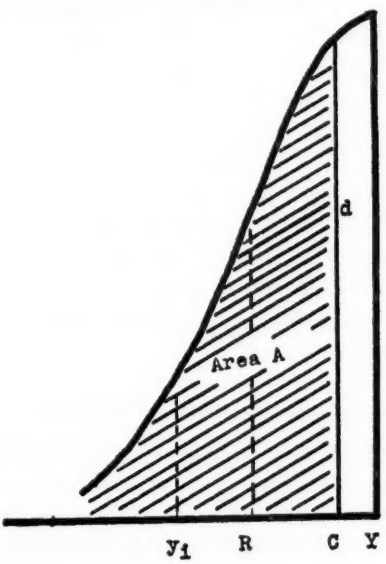

FIGURE 1

[1] For proof see Mathematical Appendix.

Then

$$L = A(C - Y) + d\sigma = 0.3897(6.9 - 7.7) + 0.3836(2.875)$$
$$= -0.312 + 1.103 = 0.8 \text{ bushel.}$$

This is the annual loss cost for one year. A similar loss cost is computed for each year in the base period. If an annual loss cost is less than the minimum (described next), the latter is used. A simple average of the annual loss costs, substituting the minimum when necessary, is the premium rate for the area at the coverage level selected.

A minimum annual loss cost per acre applies. It amounts to $0.01152\overline{Y}$, or a little more than 1 per cent of the long-term county or area-average yield. For the example, $0.01152\ (11.5) = 0.132$ bushel. If an annual loss cost is computed at less than the minimum, the latter applies for that year. Then, as stated previously, the average annual loss cost or premium rate applicable to all farms in the area is the simple average of the annual loss costs, adjusted upward for those years in which the minimum applies.

Assumptions

Three assumptions are inherent in the FCIC formula (1) that the area-average investment costs (which cannot be exceeded by law) is equal to 60 per cent of the long-term area-average yield, (2) that the standard deviation σ of acre yields y_i around Y for each year amounts to $0.25\overline{Y}$, and (3) that $0.01152\overline{Y}$ establishes a proper minimum annual loss cost.

When 60 per cent of the long-term area-average yield exceeds investment cost, it is possible to compute a reduced coverage (in bushels or other commodity units) by dividing the investment cost by the guaranteed price p per unit. The revised coverage so calculated can then be substituted for C in the calculations, and assumption (1) is abandoned.

Assumptions (2) and (3) are based on experience. Assumption (2) probably raises the greatest number of questions. Under it, the variability of acre yields remains constant from year to year, regardless of whether the area yield is high or low. The "spread" of the curve remains fixed. It would seem that the standard deviation of acre yields might be greater when the area yield is high than in years when it is low. Perhaps the validity of this assumption can be further tested.

Formula Suggested for Ceylon

Under the Ceylon proposal, the amount of an indemnity would not depend on the individual yields of growers. All growers (or none of them) would receive indemnities in the same year. The insurance "spread" would be over time rather than geographically, i.e., vertically rather than horizontally. Whether or not an indemnity were payable would depend only

upon the area annual yield. Thus an "area" plan of insurance is contemplated.[2]

Under the proposed plan of insurance, the indemnity payable in a particular year in an area would be (1) the coverage, multiplied by (2) the percentage of damage. The coverage is defined as half the long-term area average yield $\overline{Y}$, multiplied by a predetermined price p per unit. As this unit price is to be fixed in advance, it can be left out of the calculations, which puts them on a commodity basis. Later, the computed loss cost L (in commodity units) would be converted to dollars, on the basis of the fixed price p, so that a premium rate in dollars per acre can be quoted to the grower.

There would be no payments to anyone in a year when the percentage of damage in an area amounts to 30 per cent or less. Thus, in insurance terminology, the plan would include a 30 per cent "minimum-loss" clause. Percentages of damage greater than 30 per cent would be payable in full.

Leaving out the price per unit p, Ceylon's indemnity formula may be expressed as follows:

Indemnity $= 0.5\overline{Y}[1-(Y/\overline{Y})]$ subject to the minimum-loss clause. This is merely coverage $\times$ percentage of damage.[3] Therefore, the loss cost per acre for one year is $0.5\ (\overline{Y}-Y)$. The grower gets half the difference between the long-term area-average yield and the area annual yield, provided the latter falls below 70 per cent of the former.

To determine a premium rate or loss cost per acre for this kind of insurance, using normal-curve methods, we think of a distribution of area annual yields Y_i around the mean yield for the area $\overline{Y}$. We want to know the proportion of years having yields below $0.7\overline{Y}$ and the mean yield R for these (the indemnity) years. We can estimate a standard deviation of the area annual yields from the base-period data. Then . . .

$$\text{Area average annual loss cost or pure-premium rate L} = \frac{0.5\Sigma(\overline{Y}-Y_i)}{N} = \frac{0.5(n\overline{Y}-nR)}{N}$$

$$= \frac{0.5n(\overline{Y}-R)}{N} \quad \text{where } Y_i < 0.7\overline{Y}$$

$$= 0.5A(\overline{Y}-R). \tag{4}$$

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[2] The Canadian Prairie Farm Assistance Act is operated as an area plan. See *Agricultural Finance Review*, November, 1955, published by Farm Economics Research Division, ARS, USDA. Other discussions of area plans include: "Actuarial Structures for Crop Insurance," by Halcrow, *Journal of Farm Economics*, August, 1949; "Temperature Insurance—An Alternative to Frost Insurance in Citrus, by Lee," *ibid.*, February, 1953; "A Specific Risk Scheme for Wheat Crop Insurance," by Sanderson, *ibid.*, November, 1943; "A Crop Insurance Proposal," by Aandahl, *Iowa Farm Science*, August, 1946.

[3] Here $Y/\overline{Y}$ is per cent recovery and $(1-Y/\overline{Y})$ is percentage of damage.

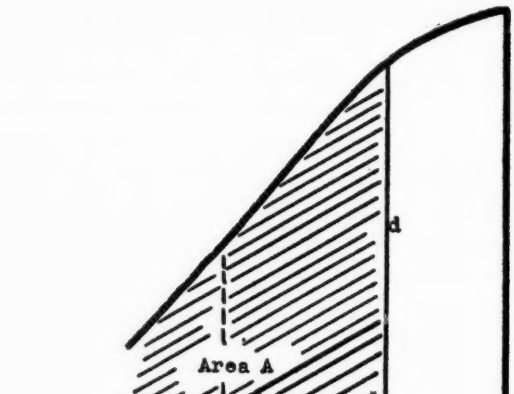

FIGURE 2

We know that

$$\frac{\overline{Y} - R}{\sigma} = \frac{\text{Height of ordinate at } 0.7\overline{Y}}{\text{Area A}} = \frac{d}{A}$$

and that $A(\overline{Y}-R)=d\sigma$. Therefore

$$L = 0.5A(\overline{Y} - R) = 0.5d\sigma. \qquad (5)$$

This formula was proposed for use in connection with the Ceylon program. In applying it, d would be determined from normal-curve values and σ would be found from the data.

Example

$\overline{Y} = 20$ bushels "Breaking point"

$\sigma = 12.4$ bushels at $0.7\overline{Y} = 14$ bushels

$$\frac{\overline{Y} - 0.7\overline{Y}}{\sigma} = \frac{6.0}{12.4} = 0.484 \text{ so } \overline{Y} - 0.7\overline{Y} = 0.48\sigma.$$

At 0.48σ (from normal-curve data)

Ordinate d (at $0.7\overline{Y}$) = 0.3555

Then

$$L=0.5d\sigma = 0.5(0.3555)(12.4) = 2.2 \text{ bushels.}$$

This average annual loss cost of 2.2 bushels, multiplied by the guaranteed price p, would establish the premium rate in dollars per acre applicable to all growers in the area.

Mathematical Appendix

1. The problem is to evaluate the mean of a truncated normal distribution. The distribution of yields for a population of N acres is approximated by a continuous variable y distributed normally with mean, Y, and variance, σ. In other words, knowing Y and σ, it is possible to use the tabled values of the normal curve to calculate the proportion of the total number of acres having yields between any pair of specified limits.

2. The population is classified into two groups—n acres yielding less than C and N−n acres yielding more than C. What is the average yield for those acres yielding less than C?

3. The average yield for the entire population would be

$$Y = \int_{-\infty}^{\infty} y \cdot f(y)dy$$

where

$$f(y) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}(\frac{y-Y}{\sigma})^2}.$$

This is analogous to the definition of a weighted average where the sum of the weights is equal to one. Here,

$$\int_{-\infty}^{\infty} f(y)dy = 1.$$

4. R is the average yield for those acres yielding less than C. A tentative definition, R′, analogous to (3) would be

$$R' = \int_{-\infty}^{C} y \cdot f(y)dy.$$

However, the weights do not add up to one,

$$\int_{-\infty}^{C} f(y)dy = A \neq 1,$$

where A=n/N, the area under the curve lying to the left of C. Therefore, the correct definition is found by dividing R′ by the sum of the weights, A.

$$R = \frac{R'}{A}$$

5. Now, we turn to the evaluation of the numerator, R′.

$$\int_{-\infty}^{C} y \cdot f(y)dy = \int_{-\infty}^{C} y \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{y-Y}{\sigma}\right)^2} dy.$$

Let

$$z = \frac{y - Y}{\sigma}, \qquad y = \sigma z + Y, \qquad dy = \sigma dz, \qquad K = \frac{C - Y}{\sigma}.$$

Then,

$$\begin{aligned}
\int_{-\infty}^{C} y \cdot f(y)dy &= \int_{-\infty}^{K} (\sigma z + Y) \frac{1}{\sqrt{2\pi}\sigma} e^{-1/2z^2} \sigma dz \\
&= \frac{\sigma}{\sqrt{2\pi}} \int_{-\infty}^{K} z e^{-1/2z^2} + \frac{Y}{\sqrt{2\pi}} \int_{-\infty}^{K} e^{-1/2z^2} dz \\
&= \frac{\sigma}{\sqrt{2\pi}} \left[- e^{-1/2z^2} \right]_{z=-\infty}^{z=K} + YA \\
&= - \sigma d + YA,
\end{aligned}$$

where d is the ordinate of the normal curve at z = k,

$$d = \frac{1}{\sqrt{2\pi}} e^{-1/2K^2}.$$

$$R = \frac{YA - \sigma d}{A} = Y - \frac{d\sigma}{A}.$$

GOVERNMENT RENTING OF ENTIRE FARMS VERSUS BUYING THEM AS A SOLUTION TO THE FARM PROBLEM

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RETIREMENT of entire farms is mentioned more and more as a proposed solution to the farm problem. To date, complete analysis has not been made of the possible methods of retiring entire farms; for example, should the government rent farms over a period of time or should farms be purchased outright? Harsh though they may appear, the government might use these methods of assistance to the almost complete exclusion of other programs. Individual farmers could participate on a volunteer basis; if farming becomes too unsatisfactory, they could simply choose these methods of bowing out. This note is not intended to discuss the merits of entire farm retirement vs. other proposed solutions. Rather,

it proposes to brief some arguments that might be considered for renting farms and some in favor of purchasing them outright.

Arguments for Government Rental of Entire Farms

1. *Easily returned to production if needed.* Suppose technological advances do not keep pace, war is declared or demand miraculously strengthens. Rental terms could be quickly cancelled, and although re-equipping and re-stocking would present a problem on some farms, the land could be returned to production and to the profit of the original owner. Considerable red tape might be involved in transferring government-owned land back into private ownership.

2. *Not as socialistic.* So many proposals involving government action have been made that hardly any panacea is unexpected. Neither of the two mentioned here (government renting or buying of entire farms) should bring acclaim from those who disdain social intervention. Renting land may meet with disfavor, but "homesteading in reverse" via government purchase may be putting the government into resource ownership farther than can be accepted. Not only the increased government stake in land, but also the *finality* of movement of human resources and capital off the land caused by it may seem to carry socialism too far.

3. *More land removed from production.* Among the alternatives an active farmer has in trying to improve his economic position, renting his farm out seems to be next to last in priority, preceding selling out. Consequently, more land should be taken out of production through the rental program than by outright purchase. Furthermore, farmers would react to it quicker. Farmers must reason that if conditions improve they can still return to farming once the lease runs out. They always have the alternative of selling.

4. *Less danger of inflation.* Public renting of farms to strengthen farm product prices to satisfactory levels may be costly. Still these are annual use payments. Purchase of the same land area, if consummated in the same year, would require considerably more funds. Deficit financing would be required which would add to the national inflationary forces.

5. *More attractive from income tax standpoint.* If a farmer rents his farm, he must expect to increase his earning power through the rental alone or a combination of rent and wages from off-farm work. Additional taxation would not concern him greatly. Liquidation of farm assets, even with capital gain privileges, can give rise to large tax burdens since many farmers show only low capital costs on their farms.

Arguments for Government Purchase of Entire Farms

As long as farmers in economic trouble can sell their farms to other farmers at high prices, the government would not be interested in buying

farm real estate. To prevent too heavy loss in assets, if land values were to fall under pressure of extremely low product prices, the government would stand ready to guarantee real estate prices at a specified level. In this manner the government would become an owner of farm real estate. Some arguments for this plan over entire farm rental are briefly mentioned.

1. *Less chance for land to be returned to production at the wrong time.* Rental terms are of short, finite duration. A portion of the land will be constantly up for rent renewal. Improved economic conditions could send much of this land into production again. This potential is desirable, in respect to the conditions mentioned in argument 1 of the preceding section, but suppose the improved conditions were temporary only? Land should not be returned to production until definite need for it has arisen. There is no stability in an in-and-out movement of land.

2. *Land removed will be more effective in reducing production.* One of the criticisms of the soil bank has been that soil-banked land returned to production is more fertile and productive than before. This same result can be expected in a total farm rental program. On the other hand, purchased land will not be returned until the country definitely needs it.

3. *Underemployed labor and capital will be forced into more profitable ventures.* Farmers renting farms to the government must be prepared to return to farming should they choose to do so at the end of the rental period. Since many would keep capital tied up in equipment, they would not be fully free to search for employment or to start a new business. Where the farm is sold to the government (or to other farmers), the farmer is free to put his capital to other uses and make more ambitious moves to find profitable employment.

4. *Less chance for year to year political maneuvering on payments to farmers.* The terms of purchasing farm real estate would be subject to heavy politics as would rental arrangements. Once proper appraisal procedure was established, the purchasing of farms could proceed year after year without too heavy pressure from politics. Rental terms are subject to change every year as are other temporary programs. These changes make the long-run execution of potentially good programs difficult.

5. *Cost of program will be lower.* It might be argued that rent should be equal to the interest on the purchased price of the real estate. Even if the problem were that simple, two different rents would be involved. Farmers could probably win on a claim for interest at farm mortgage rates at least. The government would finance the purchase of land through government bonds at a lower interest level.

Rent must cover property taxes. The government may provide state and local governments with some of the lost tax revenue but hardly the full

amount of the taxes lost. Payment would at least be reduced by the amount of lowered cost of government.

Rental terms must include an allowance for the alternate opportunity cost of idle labor and capital. There is no offsetting charge for the purchased land plan.

Rental terms must cover maintenance cost on the farm. Some government-owned facilities must also be maintained. It is hard to tell which cost would be higher here.

If the recent test made by the government is any indication, the rental program could become almost prohibitively costly. From unofficial reports it appears that farmers were expecting rent equivalent to earning on both capital and labor invested. In other words, they requested rent which would yield them as much purchasing power as if they operated the farm themselves even though they were free to seek other employment. It seems quite clear that finally established rent would be somewhat higher than the minimums mentioned above.

The purchase program would accelerate at first, but after a few years, some sort of equilibrium should be attained. The rental plan requires annual renewal for many years.

Finally, when need arises for the land retired into the public domain, it could be returned via auction with the result that the general public would recover much of the investment it had made in the land. At that time it would have the pleasure of drawing upon a true soil bank.

TELEPHONE INTERVIEWING

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ANY data-gathering technique is most appropriate in certain research designs and not in others. The purpose of this article is (1) to discuss the advantages and limitations of *telephone interviewing* and (2) to describe the types of research situations for which this technique is appropriate.

Methodology

The data upon which the present article is based come from two research studies, one of which was an investigation of the consumption of dairy products in nine major Ohio cities in 1954-56. Over 8,000 urban households were contacted by telephone interviews, and in a control sample in two of the cities over 200 households not having telephones were interviewed personally so as to enable a comparison of phone to non-phone families.

The second study was an investigation of consumer purchases of Christmas trees in eight Midwestern states. Personal and telephone interviews were completed with over 3,000 housewives in 1956. Personally interviewed respondents in Columbus, Ohio made up a subsample and were asked whether they had a telephone listing in the Columbus directory so that a comparison of families with and without telephone listings could be made.

Advantages of Telephone Interviewing

Cost

One of the important advantages of telephone interviewing over other data-gathering methods is its relative cost. For each completed interview in the dairy products study, the telephone interviews required an average of 12 minutes and our in-person interviews averaged 32 minutes. The time and cost of travel is a major savings. Call-backs and sample redraws are also effected with less cost and effort.

Although exact cost data are not available from this study, other authors have provided evidence that telephone interviewing is much more economical than either the mailed questionnaire or the personal interview.[1] Baeza[2] reported the average cost of telephone interviews at 44 cents, mailed questionnaire responses at 54 cents, and personal interviews at $2.72.

Rate of Response

Today's housewife is a "slave" to the telephone. She is less reluctant to answer it than to open her door to a stranger with an interview schedule in hand. The rate of response from the dairy consumers in nine Ohio cities ranged from 93 to 99.6 per cent. Only 1.6 per cent of the 8,000 households in the sample could not be contacted after seven calls (not including busy signals) with at least two calls in each the morning, afternoon and evening periods. A similar experience with personal interviews averaged from 9 to 16 per cent refusals or not-at-homes (even with three call-backs).

In the Midwestern forestry marketing project, the states using telephone interviews had a 5 per cent lower refusal rate than states utilizing personal interviews. Identical questionnaires were used with both data-gathering methods.

Refusal rates for telephone interviewing have generally been found to

[1] Stanley L. Payne, "Some Advantages of Telephone Surveys," *Journal of Marketing*, XX, January, 1956, pp. 278-281.

[2] M. A. Baeza, "Sampling and Response Difference for Three Methods of Enumeration Obtained in a Study of Consumer Potato Preference," Ph.D. Thesis, Michigan State University, 1950, p. 23.

be from 2 to 5 per cent, for personal interviewing from 5 to 15 per cent, and for mail questionnaires as large as 50 per cent.

If reinterviews are planned at a later time, the telephone interview also has the advantage of leaving the respondent with a more pleasant attitude toward the interviewer. In the forestry consumer study, 85 per cent of the respondents said they "liked" being interviewed by phone. When asked whether they preferred telephone or personal interviews, more of the respondents were in favor of the former. Seventy-eight per cent preferred the phone interview and 20 per cent preferred the personal interview (2 per cent were undecided).

Control Over Interviewers

Correct interviewing requires skill, and it is an arduous and seldom financially rewarding activity. One marketing researcher[3] feels that "dishonesty of interviewers remains the greatest challenge to successful field work." Many interviewers (knowingly or not) will deviate from a prescribed series of questions after repeated interviewing. They will influence responses or fail to ask questions for which they anticipate a certain reply.

Many of these problems involving interviewer skill may be absolved by properly supervised telephone interviewing. Constant supervision was maintained over a staff of centrally located phone interviewers. Completed schedules were edited quickly, checked with the interviewer and, if necessary, the respondent was reinterviewed. Overt cheating by interviewers was more difficult than in personal interviewing. Of course, these advantages of telephone interviewing could not be secured if the interviewing was unsupervised or "farmed out" to interviewers in separate locations.

Other Advantages

There are additional advantages when it is necessary to interview certain nationality groups. A bilinquist can be utilized more effectively and efficiently in telephone interviewing than in personal interviewing. In contacting dairy consumers in Cleveland, interviewers could speak a total of seven different languages with little loss of efficiency. Several respondents used a foreign language to discourage unknown callers. They would often revert to English after the telephone interviewers indicated ability to also converse in their foreign tongue.

The telephone interview also removes some of the biases present in the personal interview. The effect of appearance, facial expressions, and mannerisms (other than vocal) are neutralized.

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[3] George Fisk, "Methods of Handling Certain Field Research Problems," *Journal of Marketing*, XII, January, 1948, p. 382.

Limitations

Bias

One of the important limitations of telephone interviewing is the bias involved in contacting only those individuals who list a telephone number in a directory. Telephone directories have been regarded as questionable sampling frames since the *Literary Digest* poll disaster in 1936. However, the use of telephones has expanded greatly since 1936. The percentage of households with listed phone numbers in the nine major Ohio cities ranged from 85 to 91 per cent.

In certain areas there is an even higher percentage of telephone saturation. In Monroe, Michigan, 95 per cent of the households have phones and in Evanston, Illinois, this figure is 97 per cent. Farm households are generally less likely to have telephones, especially in the South. Only 19 per cent of the Alabama farms have phones while the high is Connecticut with 94 per cent.

Telephone saturation may closely approach 100 per cent for certain occupations or businesses. For example, a random sample of drug stores in a city may be drawn from the classified directory.

Nontelephone biases may also be corrected with a supplemental personal interview. Most large metropolitan centers have street directories which list all households, including those who do not have telephones. This approach was utilized in the dairy consumer study in Akron and Dayton. Telephone households were compared to nonphone households both within the census tract and within the metropolitan center. No significant differences were found on the basis of (1) per capita consumption of milk, (2) per cent of milk that was home delivered, (3) family size, and (4) family income. Baeza[4] reported generally similar findings in Michigan as to the characteristics of phone and nonphone households.

As part of the Christmas tree study in Columbus, the 61 nonphone householders were queried as to reasons why they did not have a telephone listed in the city directory. Reasons were: change of residence and new directory not yet published since phone was installed (36 per cent); did not want to be bothered with a telephone (19 per cent); illness in the family (9 per cent); avoiding solicitors (9 per cent); family troubles (6 per cent); avoiding customers or clients (6 per cent); and other reasons (10 per cent). Change of address is the most important single reason that a household did not have a phone number listed in the directory. About 20 per cent of the U. S. population changes residence each year.

Length of Interview

The length of time that respondents are willing to converse is a limitation of telephone interviewing. The authors had good success in main-

[4] *Op. cit.*

taining rapport through 20 question interviews that required an average of six to seven minutes. Respondents tended to underestimate the length of the conversation by one-third. Boyd and Westfall[5] reported telephone interviews of 20 minutes duration.

Type of Information

There are certain limitations in regard to the type of information that may be secured. Visual materials, including visual projective techniques, cannot be utilized in telephone interviewing. With this exception, in this survey almost any information which could be secured in personal interviews could also be collected via telephone. Other researchers have reported a similar experience.[6]

Conclusion

When compared to personal interviews or mailed questionnaires, telephone interviewing is characterized by a lower per interview cost, a higher rate of response, and a greater degree of control over interviewers. Telephone directories may in some instances provide a biased sample of the population (this, of course, depends upon the nature of the population). Telephone interviews must be of limited duration, and visual materials cannot be used as part of the interview.

Telephone interviews may be used in imaginative combinations with other data-gathering techniques. For instance, the authors have utilized telephone interviews in following up the nonrespondents to a mailed questionnaire. Phone interviews have also been used to reinterview respondents originally contacted three months earlier via personal interview.

Thus, telephone interviewing should be regarded as a highly useful data-gathering tool for social science researchers.

[5] Harper W. Boyd, Jr. and Ralph Westfall, *Marketing Research*, Homewood, Illinois: Richard D. Irwin, Inc., 1956.

[6] For example, Payne, *op. cit.*

A NOTE ON 'AN AGGREGATE SUPPLY FUNCTION FOR NEW ZEALAND WHEAT'

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AS A MENTAL exercise in multiple correlation methods, Candler's recent article on the supply function for New Zealand wheat possibly has some value.[1] But it would be unfortunate if American readers

[1] Wilfred Candler, "An Aggregate Supply Function for New Zealand Wheat," *Journal of Farm Economics*, Vol. 39, No. 5, December 1957, pp. 1732-1741.

assumed that the conclusions reached concerning the possible ways of altering the wheat acreage in New Zealand were valid. In fact, two of the suggestions are nonsense and reveal the extreme danger of playing around with this sort of analysis without a sound and practical knowledge of the farming practices involved. This is a situation in which there seems to be a propensity to produce a lot of numbers, which appear to be sound statistically, but which do not make sense to those familiar with the farming methods and human factors involved.

In the first place, the article concludes that we may have more wheat if the price is higher or if the price of fat lambs is lower, relatively. There is no argument with this, of course, for these products have been competitive and substitutable on many types of farms since the advent of refrigeration. But to suggest in all seriousness that the "most effective policy would be a levy on fat lambs in the wheat producing provinces, the resulting income to be paid back to the farmers in the form of increased price for wheat" is quite fantastic. Can the reaction of hundreds of farmers in wheat growing provinces, whose farms in terms of soils, climate, fertility and other factors are not suitable for wheat growing, be imagined? And what about the hundreds of farmers who just do not want to grow wheat?

Fortunately, the New Zealand farmer remains the sole decision maker so far as the use of his resources is concerned. The tenor of the above suggestion, namely that some farmers subsidize others, is such that American readers might imagine that this sort of interference with the economic liberty of farmers is tolerable to them. That is not so.

Candler's third suggestion, that the government might reduce the area sown to red clover, is equally misleading. Red clover seed production in practice bears only a vague relationship to wheat production, insofar as in one wheat growing area red clover is successful and sometimes profitable. This may encourage numbers of farmers to have more pasture and less cultivation, which is what they want to do anyway because of the relative profitability of sheep. (Small seeds production is in association with fat lamb farming, on the same pastures.) Candler states that the inclusion of red clover acreage as one of his independent variables "was due to the harvesting of this crop so late in the season that it may interfere with the preparation of land for wheat." Wheat sowings in New Zealand follow a summer fattening crop, such as rape, other cash crops such as peas, potatoes or wheat, and occasionally pasture which is skim ploughed before red clover seed could possible be harvested.

One can only emphasize that if intellectual exercises of this nature are to be published, considerable care should be taken to determine beforehand whether any conclusions or suggestions are technically and socially practicable.

ON NEW ZEALAND WHEAT: A REPLY

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STEWART'S criticism reduces to:

1. A general hostility to this particular "intellectual (or mental) exercise."

2. The assertion that red clover acreage does not affect wheat acreage.

3. The assertion that farmers would not tolerate the interference with their economic liberty involved in an income transfer.

In response I can only say:

1. I am sorry he feels this way, but measurement is essential if we are to make economics in any way an exact science. He will recall from reading my thesis or *The Wheatgrower,* that in November 1944 the wheatgrowers' representatives assured the government that if the price for the 1946 harvest was raised from 6s.6d. to 7s. per bushel, 300,000 acres would be planted.[1] The price rise was granted, and the wheat acreage planted was only 161,000 . . . *a prediction error of 139,000 acres, by men who should have had an eminently "sound and practical knowledge of the farming practices involved."* I very seriously doubt whether my supply function (red clover acreage and all) could have given quite such a wildly erroneous prediction!

2. Stewart says "occasionally pasture . . . is skim ploughed (for wheat) before red clover seed could possibly be harvested". *Exactly,* if red clover seed is to be harvested, *it will be too late to plough for wheat.* There is no argument here. However, I do not wish to be dogmatic as to the importance of red clover acreage. Stewart will recall that in discussing this variable I said that *multicollinearity* with days wet prevented us from saying whether red clover acreage was important itself, or was merely a good index of days wet.

3. In the 1930's the New Zealand wheat price was kept above the world price. Not only was this "interference with the economic liberty of farmers" tolerated by them, it was actively encouraged. In the late 1940's the domestic wheat price was kept below the world price. This *was* tolerated, although not encouraged, by the wheat farmers. Now, as to the policy implications, Stewart has a good and generally accepted point[2] that in making policy recommendations economists should consider their recommendations' social acceptability. We have seen that in the past, at

[1] In replying to these criticisms I think it fair to assume that since J. D. Stewart is in New Zealand he has read my Master's thesis, (mentioned in footnote 2 of my paper), "An Aggregate Supply Function for New Zealand Wheat," Master's thesis, Massey College Library, New Zealand, p. 27.

[2] See, however, the opening paragraphs of Martin Bronfenbrenner, "Changing Fashions in Philosopher-Salesmen," *Review of Economics and Statistics,* August, 1954.

least, some income transfers have been acceptable to the New Zealand wheat farmer. I *happen* to think that the furthest the government should have gone in acceding to the wheat farmers interwar demands for increased wheat price was the income transfer advocated. By the same token I *happen* to think that the farmers should have been given the world price for wheat after the war. Clearly the above are value judgements, and had I had Stewart's criticism earlier, I would have been quite willing to substitute "A policy," for "Probably the most effective policy." I do not think the substance or value of my article would have been greatly changed.

Finally, may I say that when Stewart feels able to express his undoubted "sound and practical" knowledge of New Zealand wheat farming in a form suitable for the prediction of future wheat acreages, from knowledge of relevant prices, he will have no more interested reader than myself. It is important to remember that we have to know not only that an increased wheat price will increase the acreage grown, but by *how much* the acreage will increase.

ESTIMATING ECONOMIES OF SCALE*

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THE PURPOSE of this paper is to report the findings of a study comparing the results derived by two alternative methods of estimating economies of scale curves.

The two estimating methods are: first, the "statistical approach," which in this case refers to the application of regression techniques to average annual cost-volume data;[1] and second, the "synthetic approach" or "building block method." The synthetic method theoretically involves the determination of the physical input-output relationships for all of the various

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** The author wishes to acknowledge the helpful criticisms of Lee Day of the Agricultural Research Service of the U.S. Department of Agriculture. Errors of fact, judgment or logic are, of course, the responsibility of the author alone.

[1] For examples of this particular type of statistical approach (on annual and shorter time period data) see following:

1. Korzan, G. E., David, A. B., and MacPherson, D.D., *Costs of Distributing Milk in the Portland Market,* Oregon Agricultural Experiment Station, Bulletin 510, 1952.
2. Knudtson, A. C., and Koller, E. Fred, *Manufacturing Costs in Minnesota Creameries,* University of Minnesota Agricultural Experiment Station, Bulletin 442, June 1957.
3. Hurt, V. G., *Costs and Efficiency of Selected Mississippi Fluid Milk Plants,* Mississippi State College Agricultural Experiment Station, Bulletin 536, August 1955.
4. *Costs of Processing and Distributing Milk in the South,* Southern Cooperative Series, Bulletin No. 45, June 1955.

possible techniques for each production process, and, the conversion of the production functions for the selected techniques into cost terms. This allows a selection of the optimum technique for each process. These individual process cost functions are then aggregated with the overhead costs[2] into a total short run cost function for a plant. The final step in estimating the economies of scale curve by the synthetic method involves the derivation of several such short run cost functions for plants covering a wide range of volume.[3,4]

The synthetic method of estimating a planning curve bears logical consistency to the theoretical formulation of the planning curve. The planning curve shows the least cost for producing any given volume, and the synthetic method is designed to develop least cost plant organizations. In theory, at least, the synthetic method of estimating develops the true planning curve.

The statistical method, as frequently applied, uses a regression technique on average annual cost-volume data[5]; the results of this method are not consistent with the theoretical planning curve because the regression line represents an average relationship and does not indicate the least cost for producing each volume.[6] Therefore, it is recognized that the statistical planning curve lies somewhere above the true planning curve.

More serious, however, the regression line may combine and confuse

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[2] Overhead costs refer to costs which are joint to two or more production processes, and cannot be measured within each separate production process; for example, heat, light and building costs are such costs, and are treated as overhead costs.

[3] For a more thorough discussion of the method see: Black, Guy, "Synthetic Method of Cost Analysis in Agricultural Marketing Firm," *Journal of Farm Economics*, Volume 37, No. 2, May 1955.

[4] For examples of applications of the synthetic method see:

1. Henry, W. F., Bressler, R. G., Jr., and Frick, G. E., *Efficiency of Milk Marketing in Connecticut*, Storrs Agricultural Experiment Station, Bulletin 259, University of Connecticut, June 1948.

2. French, B. C., Sammett, L. L., and Bressler, R. G., Jr., *Economic Efficiency In Plant Operations With Special Reference to the Marketing of California Pears*, Hilgardia 24:19, July 1956.

3. Brewster, J. M., *Comparative Economics of Different Types of Cottonseed Oil Mills and Their Effects on Oil Supplies, Prices and Returns to Growers*, Government Printing Office, Washington, D.C. Agricultural Marketing Service Research Report, No. 54.

4. Walker, S. H., Preston, J. J. and Nelson, G. T., *An Economic Analysis of Butter-Nonfat Dry Milk Plants*, Idaho Agricultural Experiment Station, Bulletin 20, 1953.

[5] The author is aware that this particular procedure, use of regression on average annual cost-volume data, is probably the least desirable of several alternative procedures. Nevertheless, numerous applications of this procedure can be found in agricultural marketing research.

[6] See Bressler, R. G., Jr., "Research Determination of Economies of Scale," *Journal of Farm Economics*, Volume 27, No. 3, August 1945. In this article Bressler suggests a regression only on the low points of the scatter diagram. This may be an improvement over a line of average relationship.

cost variations that result from variations in the level of utilization of plants with the variations that result from increased plant size.[7] It is the magnitude of any such possible distortion in the shape of the planning curve that is of particular concern here.

The statistical method of estimating a planning curve is far less costly than the synthetic method. The synthetic method requires a detailed analysis of the physical input-output relationships for all the various alternative techniques available—and obtaining the data is costly. Thus, it is important to determine whether or not the magnitude of the distortion introduced by the statistical method is so large as to render the results valueless.

In this study the two estimating methods were applied to the problem of determining the planning curve or economies of scale curve for specialized butter plants receiving only whole milk.[8]

The Synthetic Method

The synthetic method was applied to develop four model butter plants of different sizes. A large share of the basic input-output data was taken from four existing butter operations. However, numerous other sources of data were used to develop least cost organizations.[9] The four synthetic plants covered a wide range of volumes—from nearly the smallest volume plant in Minnesota, to a plant with a capacity approximately twice the volume of the largest specialized butter plant in the state.

The average cost-volume relationships for each of the four synthetic plants are shown in Table 1.

The economies of scale curve estimated by the synthetic method is shown in Figure 1. (See the lower dotted line BB secant through the cost-capacity points of the four plant cost curves.) The dotted line BB is shown as a smooth curve. This implies that an infinite number of plant sizes are possible, and the costs for every possible plant are known. Neither is the case, however; the smooth curve was drawn as an approximation of the economies of scale curve from a knowledge of the four points. Since the synthetic method does provide a way to estimate the economies of scale curve that is logically consistent with the theoretical concept of the

[7] Bressler, R. G., Jr., "Research Determination of Economies of Scale," *Journal of Farm Economics*, Volume 27, No. 3, August 1945; and Erdman, H. E., "Interpretations of Variations in Cost Data for a Group of Individual Firms," *Journal of Farm Economics*, Volume 26, No. 2, May 1944, hypothesized this problem of confounding level of plant utilization and economies of size.

[8] For the complete study see: Knudtson, A. C., *An Analysis of Processing Costs in Specialized Butter Plants Receiving Whole Milk*, Unpublished Ph.D. thesis, University of Minnesota 1957.

[9] These were least cost organizations within the limitations of the technical information available to the author.

TABLE 1. ANNUAL AVERAGE COST PER HUNDREDWEIGHT OF MILK IN FOUR MODEL PLANTS

Volume of milk	Average total cost per hundredweight of milk			
	Plant No. 1	Plant No. 2	Plant No. 3	Plant No. 4
(thousand pounds)	(cents)			
7,300	48.8			
10,950	33.7			
14,600	26.2			
18,250	21.7	28.5		
21,900	18.7	24.2		
25,550		21.2		
29,200		19.0	23.5	
32,850		17.2	21.3	
36,500		15.8	19.6	
40,150		14.7	18.1	
43,800		13.7	17.0	
47,450			16.0	
51,100			15.1	17.4
54,750			14.4	16.6
58,400			13.7	15.7
62,050			13.1	15.0
65,700			12.6	14.4
69,350			12.2	13.9
73,000			11.8	13.4
76,600				12.9
80,300				12.5
83,950				12.1
87,600				11.8
91,250				11.4
94,900				11.1
98,500				10.9
102,200				10.7
105,850				10.5
109,500				10.3

economies of scale curve, the synthetic method, BB, curve will be referred to as the true planning curve.[10]

The Statistical Method

The statistical method as applied represents a very simplified illustration of the difficulties involved in using a simple regression technique on average annual cost-volume data. The method was applied to hypothetical average annual cost-volume accounting data. These hypothetical data were derived as follows: each of four annual average cost-volume points were read from the four respective synthetic plant cost curves. The particular volume selected in each case represented the annual average volume experienced in each of the respective actual plants.

The average annual cost-volume positions thus established are shown

[10] For a discussion of the theoretical formulation of the economies of scale curve see: Stigler, G., *The Theory of Price*, Revised Edition, Chap. VIII "Returns to Scale and Long Run Cost Curves," pages 134-146, Macmillan Publishing Co., New York, 1953.

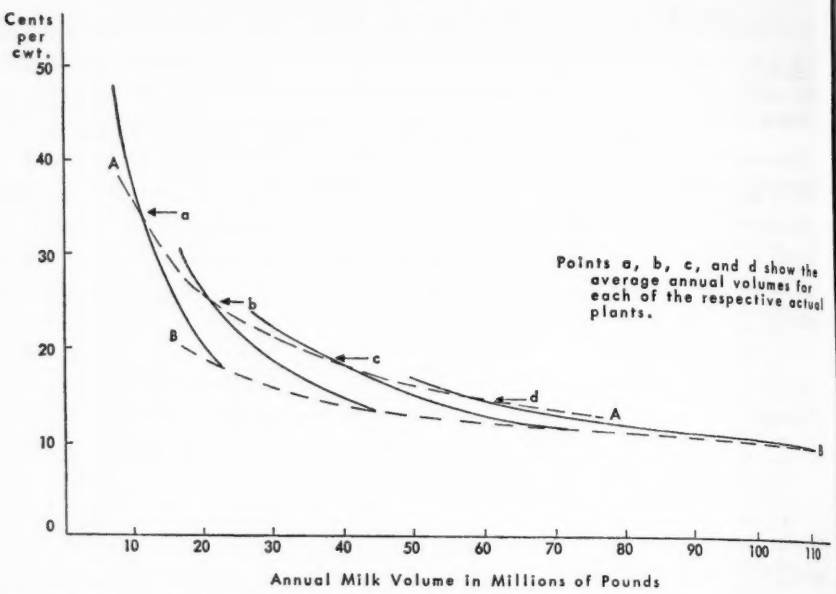

FIG. 1. ANNUAL AVERAGE TOTAL COST CURVES FOR FOUR MODEL PLANTS SHOWING THE STATISTICAL AND TRUE PLANNING CURVES

in Table 2 and plotted on the individual plant cost curves. (See points a, b, c, and d, Figure 1.) The dotted line AA is a hand fitted line representing the line of average relationships between costs and volume of the observations involved; this line is the statistical planning curve.

TABLE 2. RELATIONSHIP BETWEEN THE ANNUAL TOTAL MILK VOLUMES AND THE AVERAGE COST PER HUNDREDWEIGHT FOR THE FOUR MODEL PLANTS

Plant Number	Annual Milk Volume	Average Cost Per Hundredweight
		(cents)
1	10,555,800	34.6
2	23,739,600	22.5
3	39,566,000	18.3
4	73,913,000	13.0

These hypothetical accounting data differ from typically used actual accounting data in that these costs have been standardized between plants. The standardization of costs such as wage rates, building costs, depreciation rates, etc., reduce the number of variables affecting the results. Since the major purpose of this paper is to compare the results obtained by either of two estimating methods (statistical and synthetic), a reduction in the number of variables affecting the results would appear desirable.

These hypothetical accounting cost data were not standardized relative to plant capacities. Table 3 shows the relationships between the average annual volumes of the actual plants on a daily basis and daily plant capacities.

TABLE 3. RELATIONSHIP BETWEEN ANNUAL AVERAGE DAILY VOLUME, AND DAILY PLANT CAPACITY FOR THE FOUR PLANTS

Plant Number	Average annual volume (daily basis)	Plant capacity daily	Per cent annual average daily volume is of plant capacity
	(pounds of milk)		(per cent)
1	28,920	60,000	48.2
2	65,070	120,000	54.2
3	108,450	200,000	54.2
4	202,440	300,000	67.5

The hypothetical accounting costs were not standardized relative to plant capacities because in the type of accounting cost studies under consideration, plant capacities are not typically determined. Probably the most important reason for not including capacity information in these studies is the fact that plant capacity information cannot be determined from accounting statements and in many cases can be determined only with considerable difficulty.

Plant capacities in the case of butter plants are reached first in storage capacities. The storage capacities of whole milk vats, buttermilk vats, skim milk vats and the ice machine are the factors that usually limit capacity in a butter plant. Actual plant No. 1, the smallest plant, had the lowest volume relative to capacity, 48.2 per cent. The largest actual plant, plant No. 4, operated at an average of 67.5 per cent of the capacity—the highest volume relative to capacity (Table 3).

In the particular case in point, the scale curve facing butter firms, the bias introduced by the confounding of levels of capacity and economies of size is toward overstating the economies that do in fact exist. (Compare the true planning curve, line BB, and the statistical planning curve, line AA, Figure 1.) In the butter industry in Minnesota, approximately 85 per cent of the butter plants in the state are cooperatively owned. A cooperative marketing firm pays its patrons everything it receives for its product over operating costs. Therefore, the firms in the lowest cost positions would pay higher prices for milk and would tend to gain volume from the lower volume firms having higher costs. This would reduce the level of capacity at which the smaller firm operates and thus increases its operating cost. A statistical estimation of the economies of scale curve based on annual average cost-volume data cannot account for these varia-

tions in levels of operation relative to plant capacity, and therefore, the level of plant capacity is confounded with the economies of size.[11]

The evidence points to the fact that the particular statistical method of estimating planning curves illustrated does not supply reliable results. A planning curve that overstates the economies of size would be, at best, worthless. Even worse, however, it would tend to mislead decision makers into over-building because the indicated economies are greater than the economies that could actually be realized.

[11] In applying a different statistical approach, for example, a multiple regression technique that would account for the per cent utilization of plant capacity, most of the problems introduced here would disappear.

A NOTE ON THE SYMMETRY OF HOMOGENEOUS PRODUCTION FUNCTION AND THE THREE STAGES OF PRODUCTION

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THE PRODUCTION function is generally divided into three stages:

"1. In the first stage the marginal product of the fixed service is negative.
2. In the second stage the marginal products of both factors are positive and diminishing.
3. In the third stage the marginal product of the variable service is negative."[1]

The three stages of production are thus defined according to the sign of the marginal productivities of the fixed and variable factors. By definition the first and the third stages are symmetrical, in that in each of these two stages the marginal productivity of one of the factors is negative.

Sometimes the border lines between the stages of production are defined in terms of the relationships that exist between the average and marginal productivities of the factors.[2] This is demonstrated in the Figure where the border line between stage I and II is drawn where MP_v (marginal productivity of the variable factor) and AP_v (average productivity of the same factor) are equal. As was pointed out by Stigler, the point of equality of MP_v and AP_v lies on the border line between the two

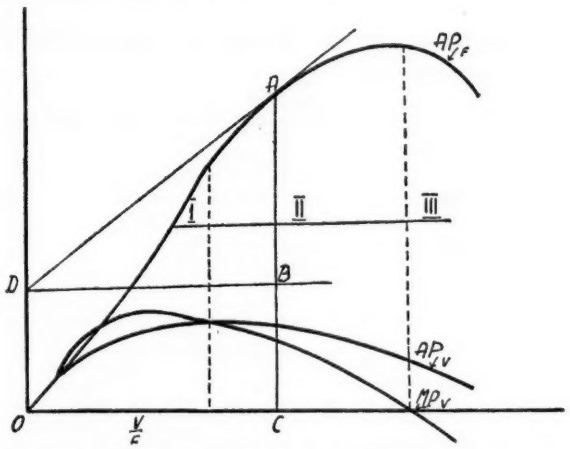
[1] Stigler, G. J. *The Theory of Price* (revised edition), New York: Macmillan, 1952, pp. 115-16.

[2] Cassels, J. M. "On the Law of Variable Proportions" in *Readings in the Theory of Income Distribution*, Philadelphia: The Blakiston Company, 1946.

Heady, E. O. *Economics of Agricultural Production and Resource Use*, New York: Prentice Hall, 1952, Ch. 4.

Bradford, L. A. and Johnson, G. L. *Farm Management Analysis*, New York: Wiley, 1953, Ch. 8.

stages only when the production function is homogeneous of the first degree.[3]



This note shows how the stages can be defined in terms of the average and marginal productivities of the factors in the more general situation when the production function is homogeneous of degree k ($k > O$) and how the definition is affected by the degree of the function. The stages are defined in terms of the elasticities of the function with respect to each of the factors, and it is shown that the symmetry between the first and the third stages inherent in the definition of the stages is preserved in the above definitions.

One should begin with the following assumption and definitions:

$$Y = f(V, F) \tag{1}$$

where Y is the output, V is the variable factor, F is the fixed factor and f is a homogeneous function of degree k, ($k > O$). By the homogeneity of the function[4]

$$Y = F^k g(V/F). \tag{2}$$

The definitions below follow from (2)

$$AP_V = \frac{Y}{V} = F^k g(V/F)/V \tag{3}$$

$$MP_V = \frac{\partial Y}{\partial V} = F^{k-1} g'(V/F) \tag{4}$$

$$AP_F = Y/F = F^{k-1} g(V/F) \tag{5}$$

$$MP_F = \partial Y/\partial F = KF^{k-1} g(V/F) - F^{k-1} g'(V/F)(V/F). \tag{6}$$

[3] Stigler, *op. cit.*, mathematical note No. 9.

[4] Allen, R. G. D. *Mathematical Analysis for Economists.* Macmillan, 1956, reprint, p. 319.

The definition of the three stages of production in terms of the average and marginal productivities of either of the two factors is summarized below:

CLASSIFICATION OF STAGES OF PRODUCTION

	Stage		
Factor	1	2	3
Variable	$\frac{MP_v}{AP_v} > k$	$0 < \frac{MP_v}{AP_v} < k$	$\frac{MP_v}{AP_v} < 0$
Fixed	$\frac{MP_F}{AP_F} < 0$	$0 < \frac{MP_F}{AP_F} < k$	$\frac{MP_F}{AP_F} > k$

The relationships presented in the table are proved below.

Theorem: When the production function is homogeneous of the k-th degree, the marginal productivity of the fixed factor is negative if and only if $MP_v/AP_v > k$. Proof: Substituting (3) and (4) in (6) one gets

$$MP_F = (V/F)[k(AP_v) - (MP_v)] \tag{7}$$

$MP_F < 0$ implies

$$[k(AP_v) - (MP_v)] < 0, \quad \text{or} \quad MP_v/AP_v > k.$$

When this ratio is smaller than k, MP_F is positive and the point is in either stage 2 or 3. The distinction between these two stages is determined by the sign of the ratio. A negative sign implies, by definition, stage 3. Therefore, stage 2 is identified with the region for which the ratio is positive and smaller than k.

In order to prove the relationships in terms of the average and marginal productivities of the fixed factor, the production function is written

$$Y = V^k h(F/V). \tag{8}$$

Since (8) is similar in form to (2), the proof is similar and can be eliminated.

The relationships displayed in the Table are actually defined in terms of the production elasticities with respect to the two factors. The elasticity coefficient of factor i is defined as:

$$E_i = \frac{\partial Y}{\partial i}\frac{i}{Y} = \frac{MP_i}{AP_i} \qquad i = V, F. \tag{9}$$

It should be noted that the symmetry of the conditions for stage 1 and 3 merely reflects two underlying assumptions: (a) the symmetry in the

definition of the two stages, and (b) the symmetry of the production function which tolerates, without being affected, a permutation of the terms "fixed" and "variable" factors. This symmetry is most clearly reflected in the following lemma;

Lemma: Given a homogeneous function of degree k, then

$$E_F + E_V = k. \tag{10}$$

This lemma is an extension of Euler's theorem,[5] deriving

$$\frac{\partial Y}{\partial V} V + \frac{\partial Y}{\partial F} F = kY$$

The lemma is proved by dividing through by Y.

According to (10), the elasticity coefficient of one of the factors is the complement of that of the other factor. Hence, if one coefficient is negative, the other should be larger than k. For instance, E_F can be negative only when MP_F is negative (stage 1), and in that case E_V must be larger than k. When one of the coefficients is positive and smaller than k, the other will also be found in the same range. A coefficient will be positive only when the marginal productivity of that factor is positive. Therefore, two positive elasticities imply stage 2.[6]

It should be noted that the conditions presented in the Table depend on the degree of function. Only in the special case when $k = 1$ will the border between stage 1 and 2 pass through the point where $AP_V = MP_V$. The relative size of stages 1 and 3 is inversely related to the degree of the function, whereas the size of the second stage is directly related to k. It can thus be concluded that when the production function displays increasing returns to scale, the rational stage (stage 2) will be defined over a wider domain of values for V/F than in case of decreasing returns to scale.

In this context it is possible to show how the marginal productivity of the fixed factor can be expressed graphically. For this purpose equation (6) is rewritten as

$$MP_F = (AP_F)k - (MP_V)(V/F). \tag{11}$$

The usual way of describing the production function graphically is to plot

[5] *Ibid.*, p. 319.

[6] As a consequence, it can be argued that the last part of Stigler's definition of stage 2 when applied to a homogeneous production function is superfluous, and may be misleading. It suffices to say that in stage 2 the two marginal productivities are positive and it is unnecessary to add that they are diminishing. Furthermore, the two marginal productivities diminish in different directions, as a given change in the ratio (V/F) will cause the marginal productivity of one factor to diminish and that of the other factor to increase.

AP_F against the ratio V/F.[7] First take up the special case where k = 1. Then refer to the Figure and identify for point A:

$$AP_F = CA, \qquad (V/F) = OC, \qquad MP_V = AB/DB$$

By substituting these identities in (11), one gets $MP_F = OD$.[8] That is, when the production function is linear and homogeneous, the marginal productivity of the fixed factor is equal to the vertical intercept of the tangent to the AP_F curve. When $MP_V = AP_V$, the tangent line starts at the origin and hence $MP_F = O$. Left to this point (stage 1) the intercept is negative and right to this point, it is positive. When it is positive and smaller than AP_F, one gets stage 2; whereas when it is positive and larger than AP_F, one gets stage 3, as this can only happen when MP_V is negative.

In the general case where the value of k is not restricted, one can rewrite (11) as

$$MP_F = AP_F - (MP_V)(V/F) + d(AP_F)$$

where $d = k - 1$. MP_F is thus equal to the intercept plus the term $d(AP_F)$. This term is negative when $d < o$ (decreasing returns to scale) and positive when $d > o$ (increasing returns to scale).

Comments

Ordinarily, a rational firm should not operate in a region where the marginal productivity of any factor is negative, that is, where the particular factor is employed in excess amount and has a detrimental effect.[9] In most discussions it is implied that the division of the production function into three stages has the virtue of limiting, on *a priori* ground without the knowledge of factor and product prices, the organization of the factors to a region where their marginal productivity is positive.

Stating the stages of production in terms of the marginal and average productivities of the variable factor is interesting by itself but can also be justified from the viewpoint of application. Sometimes it may be easier to evaluate the productivity of the variable factor when the quantity of the other factors remain fixed. A case in point is the estimation of the production function from experimental data in agriculture. In this case where the marginal productivity of the fixed factor is not evaluated directly, it will not suffice to state that one should avoid the region where the marginal product of the fixed factor is negative. Here it seems advantageous to state the regions according to the productivity of the vari-

[7] Sometimes AP_F is termed loosely as the total product when its actual meaning is the total product per unit of the fixed factor. (See also 8)

[8] A similar proof is presented in Allen, *op. cit.*, p. 321. Allen proves that the vertical intercept is equal to $F(\delta Y/\delta F)$ and this is equal to MP_F only when $F = 1$. This is the only case to which his set up applies. (See Fig. 84 there.)

[9] Exceptions might arise in situations of monopolistic pricing.

able factor. However, with this the problem is not completely solved. The previous section attempted to show that the distinction between stage 1 and 2 when the production function is homogeneous of degree k, assumes the knowledge of the degree of the function (which can also be referred to as the scale coefficient) since the border line itself is a function of the scale coefficient.

It should be mentioned that, strictly speaking, the definition of the marginal productivity of a factor as used above (see (4) and (6)) is only applicable when the factor is completely divisible. Whether factors of production are divisible or not is a question about facts and to answer it via a discussion is a poor substitution, for empirical evidence. In general, it seems that the variable factors are divisible. But are the fixed factors indivisible? There is no doubt that some fixed factors are indivisible; however, fixity does not imply indivisibility. Factors can be fixed economically or institutionally but technically divisible.[10] The substitute for empirical evidence here is recent research work in farm planning and examination of the limitational factors which include those factors whose quantity cannot be increased during the period of planning. Among the fixed factors, and high on the list, are land, labor, production capital and water, all of which are divisible. Factors such as buildings or machinery may be considered indivisible, but even here this position could be hard to defend in some situations. It is not defended here because, the main point was to argue that the definitions are not only correct mathematically but are also applicable and meaningful in some cases.

At the end, it is desirable to emphasize that the results obtained only hold for a homogeneous production function. What happens when the function is not homogeneous is, to the writer's knowledge, an open subject.

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[10] The definition suggested by Johnson is: "Assets remain fixed when their value in use is less than the cost of getting more of them and more than what can be realized from them in their most profitable alternative use." Johnson, G. L. "Problems in Studying Resource Productivity and Size of Business Arising from Managerial Processes," in Heady, E. O., Johnson, G. L. and Hardin, L. S., Ed., *Resource Productivity, Returns to Scale, and Farm Size,* Ames: The Iowa State College Press, 1956, p. 17.

BOOKS RECEIVED

Allen, R. G. D., "Mathematical Economics," New York: St. Martin's Press, Inc., 1957. Pp. xvi, 759. $7.50.

Chamberlin, Edward Hastings, "Towards a More General Theory of Value," New York: Oxford University Press, 1957. Pp. xii, 318. $5.00.

Cohen, Jerome B., "Japan's Postwar Economy," Indiana: Indiana University Press, 1958. Pp. xvii, 262. $6.50.

Crisp, Richard D., "Marketing Research," New York: McGraw-Hill Book Co., Inc., 1957. Pp. xii, 798. $7.50.

Denman, D. R., "Origins of Ownership," London: George Allen and Unwin, Ltd., 1958. Pp. vii, 190. 22s. 6d.

Farnsworth, Helen C., "Multiple Pricing of American Wheat," Stanford: Stanford University Press, 1958. Pp. 50. $1.00.

Harris, Seymour E. (Ed.), "Problems of International Economics," special conference series 9, *Review of Economics and Statistics*, Supplement February 1958, Cambridge: Harvard University Press, February 1958. Pp. 142. $1.50.

Harriss, C. Lowell, "Selected Readings in Economics," New Jersey: Prentice-Hall, Inc., 1958. Pp. xi, 546. $3.95.

Heady, Earl O., Howard G. Diesslin, Harald R. Jensen and Glenn L. Johnson (Eds.), "Agricultural Adjustment Problems in a Growing Economy," Iowa: Iowa State College Press, 1958. Pp. xi, 315. $3.95.

Krutilla, John V. and Otto Eckstein, "Multiple Purpose River Development," Baltimore: The Johns Hopkins Press, 1958. Pp. xiv, 301. $4.50.

Mikesell, Raymond F., "Agricultural Surpluses and Export Policy (Monograph)," Washington, D. C.: American Enterprise Association, 1958. Pp. v, 52. $1.00.

Smith, Alfred Glaze, Jr., "Economic Readjustment of an Old Cotton State, South Carolina, 1820-1860," Columbia: University of South Carolina Press, 1958. Pp. viii, 239. (No price listed.)

The Ministerial Committee for Agriculture and Food, "Agricultural Policies in Europe and North America," Paris: The Organization for European Economic Co-Operation, 1957. Pp. 443. $4.50.

Trager, Frank N., "Building a Welfare State in Burma, 1948-1956," New York: Institute of Pacific Relations, 1957. Pp. x, 118. $4.00.

Weintraub, Sidney, "An Approach to the Theory of Income Distribution," Philadelphia: Chilton Co., 1958. Pp. x, 214. $6.50.

BULLETINS RECEIVED

Bonser, H. J., "Part-Time Farming in the Knoxville City-Country Fringe," Tennessee Agr. Expt. Sta., Bul. 270, September 1957.

Branan, N. Carson and W. D. Toussaint, "An Economic Analysis—North

Carolina Lettuce Marketing Practices," A. E. Information Series No. 64, North Carolina Agr. Expt. Sta., February 1958.

Byrnside, D. S., Jr. and M. B. Sturgis, "Soil Phosphorus and Its Fractions As Related to Response of Sugar Cane to Fertilizer Phosphorus," Louisiana Agr. Expt. Sta., Bul. 513, March 1958.

Corty, F. L. and J. C. Purcell, "Consumption and Demand, Fluid Milk, and Fluid Milk Substitutes in the Urban South," Southern Cooperative Series, Bul. 53, October 1957.

Cable, C. Curtis, Jr. and Shelby H. Holder, Jr., "Use of Fiber Testing in Marketing Arkansas Cotton," Arkansas Agr. Expt. Sta., Bul. 594, November 1957.

Fischer, George H., "Legal Aspects of Farm Tenancy and Sharecropping in South Carolina," South Carolina Agr. Expt. Sta., Bul. 449, June 1957.

Lindberg, R. C. and G. G. Judge, "Estimated Cost Functions for Oklahoma Livestock Auctions," Oklahoma Agr. Expt. Sta., Bul. B-502, January 1958.

Maitland, Sheridan T. and Dorothy Anne Fisher, "Area Variations in the Wages of Agricultural Labor in the United States," U. S. D. A., Tech. Bul. 1177, March 1958.

Purcell, Joseph C., "Analysis of Demand for Fluid Milk and Fluid Milk Substitutes in the Urban South," Georgia Agr. Expt. Sta., Bul. N. S. 12, October 1957.

Purcell, J. C., "Analysis of Grade-Price Relationships for Cattle and Calves Sold on Georgia Markets," Georgia Agr. Expt. Sta., Bul. N. S. 46, October 1957.

Rogers, George B., William F. Henry, Alfred A. Brown and Edwin T. Bardwell, "Marketing New England Poultry. 1. Characteristics of the Processing Industry," New Hampshire Agr. Expt. Sta., Bul. 444, September 1957.

Skrabanek, R. L., Loyd B. Keel, and Louis J. Ducoff, "Texas Farmers and Old Age and Survivors Insurance," Bul. 886, Texas Agr. Expt. Sta., USDA, January 1958.

Sullivan, Gene D. and Fred H. Wiegmann, "Irrigation Costs and Returns for Cotton in the Mississippi and Red River Delta Areas of Louisiana," Louisiana Agr. Expt. Sta., Bul. 512, February 1958.

Tarver, James D., "Oklahoma Farm Manpower Needs," Oklahoma Agr. Expt. Sta., Bul. B-505, April 1958.

Taylor, C. C. and G. H. Aull, "A Practical Approach to Improving Farm Real Estate Assessment in South Carolina," Clemson Agr. Expt. Sta. and USDA, Bul. 450, June 1957.

Tolley, George S. and Cleon Harrell, "Inventories in the Meat-Packing Industry," North Carolina Dept. Agr. Econ., Raleigh, North Carolina,

A. E. Information Series No. 58, December 1957.

Tucker, E. A., "Determining the Value of Growing Crops," Oklahoma Agr. Expt. Sta., Bul. B-503, January 1958.

Woodworth, Roger C., Roy E. Proctor, Glen W. Burton, and Arthur B. Mackie, "Profitable Use of Fertilizer in the Production of Coastal Bermuda in the Coastal Plain Area of Georgia," Georgia Agr. Expt. Stas. and Tennessee Valley Authority, Bul. 13, November 1957.

MISCELLANEOUS PUBLICATIONS RECEIVED

"A Bibliography of Dissertations and Theses on Cooperatives," compiled by Wendell McMillian, USDA, FCS, Gen. Rept. 42, March 1958.

"Advertising and Promotion of Wheat and Other Foods," John A. Schnittker and William L. Ruggels, Kansas Agr. Expt. Sta., Circular 353, February 1958.

"Agricultural Trade with the Cooperatives of Japan," John H. Heckman, USDA, FCS, Foreign Agri. Rept. 105, November 1957.

"Annual Report of the Secretary General, 1956-1957, Organization of American States," Pan American Union, Washington, D. C., 1957.

"Applications of Atomic Science in Agriculture and Food," The Organisation for European Economic Co-Operation, Rept. of Mission to the U. S., Project No. 396, Paris, February 1958.

"Application of Linear Programming to Crop Competition Study in Taiwan (With Special Reference to Rice and Sugarcane Competition in Central Taiwan), S. C. Hsieh, Chinese-American Joint Commission on Rural Reconstruction, Economic Digest Series 10, October 25, 1957.

Araneta Journal of Agriculture, Vol. IV, No. 3, July-Sept. 1957, Philippines, Araneta Institute of Agriculture.

"Boletin Estadistico Banco de Guatemala," Banco de Guatemala, Guatemala, C. A. Ano X, No. 12, December 1957.

"Capital and Credit in Agriculture: Australia, W. Germany, Greece, Italy, Japan, Yugoslavia," *International Journal of Agrarian Affairs*, Vol. II, No. 4, January 1958, Oxford University Press, London.

"Compilation of Statutes Relating to Marketing Activities, Including Research, Service, and Regulatory Work of the Agricultural Marketing Service, USDA," Agriculture Handbook 130, January 1958.

"Contract Interest Rates on Farm Mortgages Recorded, January Through March 1957," Farm Economics Research Division, ARS, USDA, ARS 43-73, February 1958.

"Control of Pests in Stored Agricultural Products with Special Reference to Grain," Organisation for European Economic Co-Operation, Project 212, report of a survey in North and South America and certain Mediterranean countries in 1954 and 1955, Paris, February 1958.

"Dairy Marketing in Southwestern Wisconsin," Truman F. Graf and L. C. Thomsen, University of Wisconsin, Dept. of Agr. Econ., Ag. Econ. 25, December 1957.

"Economic Considerations in the Formulation and Repayment of California Water Plan Projects," Stanford Research Institute, SRI Project No. 1-2300, California, March 1958.

"Effect of Temperature and Shell Treatment on Egg Quality," Martha E. Hollinger, Louisiana Agr. Expt. Sta., Circular 48, June 1957.

"European Free Trade," Reginald Maudling, European Productivity Agency, No. 28, February 1958.

"Fats and Oils," *Commodity Reports,* No. 7, December 1957, Food and Agriculture Organization of the United Nations, Rome.

"Fatis Review," Food and Agriculture Technical Information Service, Vol. V, No. 1, January-February 1958, Organisation for European Economic Co-Operation, Paris.

"Farm Population-Estimates for 1957," AMS, USDA, AMS-80, February 1958.

"Food Production for Home Use by Households in the United States—by Region," Household Food Consumption Survey 1955, Report No. 12, USDA, Washington, January 1958.

"Forest Credit in the United States," Committee report by Resources for the Future, Inc., Washington, April 1958.

"General Fertilizer Recommendations for Louisiana," Louisiana Agr. Expt. Sta., Circular No. 51, January 1958.

"Headliner, A New Strawberry Variety," P. L. Hawthorne, J. C. Miller, W. F. Wilson, Jr., N. L. Horn and W. A. Sistrunk, Louisiana Agr. Expt. Sta., Circular No. 50, October 1957.

"Improving Livestock Marketing Efficiency, A Study of Nine Cooperative Livestock Markets in Ohio, Indiana and Michigan," Ira M. Stevens and R. L. Fox, FCS, USDA, Gen. Rept. 39, January 1958.

"Inedible Offal as a Hog Feed, Processing and Feeding by Small Slaughterers," Bert D. Miner, FCS, USDA, Gen. Rept. 37, December 1957.

"Interstate Trucking of Fresh and Frozen Poultry Under Agricultural Exemption," James R. Snitzler and Robert J. Byrne, AMS, USDA, Mktg. Res. Rept. 224, March 1958.

"Inventory Management by Selected Retail Farm Supply Co-ops, (Area 1—Michigan, Indiana, Ohio, Pennsylvania)," John M. Bailey, FCS, USDA, Gen. Rept. 38, January 1958.

"Italian Affairs," Presidency of the Council of Ministers of the Italian Republic, Information Office, Rome, Vol. VI, No. 6, November 1957.

"Italian Affairs," Presidency of the Council of Ministers of the Italian Republic, Information Office, Rome, Vol. VII, No. 1, January 1958.

"Livestock Auction Markets in the United States," Gerald Engelman and Betty Sue Pence, AMS, USDA, Mktg. Res. Rept. 223, March 1958.

"Marketing Meat-Type Hogs, Problems Practices, and Potentials in the United States and Canada," Gerald Engelman and Raymond O. Gaarder, AMS, USDA, Mktg. Res. Report 227, April 1958.

"Market Outlets for Livestock Producers," Victor B. Phillips and Gerald Engelman, AMS, USDA, Mktg. Res. Rept. 216, March 1958.

"Monthly Bulletin of Agricultural Economics and Statistics," Vol. VI, No. 12, December 1957, Food and Agriculture Organization of the United Nations, Rome.

Ibid., Vol. VII, No. 1, January 1958.

Ibid., Vol. VII, No. 2, February 1958.

Ibid., Vol. VII, No. 3, March 1958.

"Mr. Chairman–," Irwin W. Rust, FCS, USDA, Information 6, December 1957.

"National Atlas of the United States," National Academy of Sciences, Map Information Office, U. S. Geological Survey, Washington 25, D. C.

"On-Truck Crating Reduces Broiler Hauling Costs," William R. Henry, A. E. Information Series No. 63, North Carolina State College, Dept. Agr. Econ., February 1958.

"Production and Marketing Practices for Mellorine, A Study of the Marketing of Frozen Desserts," AMS, USDA, Mktg. Res. Rept. 212, February 1958.

"Production Practices and Requirements for Selected Silage Crops, Piedmont Area of South Carolina," Dennis E. Crawford, South Carolina Agr. Expt. Sta., AE 128, October 1957.

"Pricing Eggs at Wholesale in New York City," John O. Gerald and Norris T. Pritchard, AMS, USDA, Mktg. Res. Rept. 210, January 1958.

"Purchasing Cooperatives–An Essential Tool for the Modern Farmer," Martin A. Abrahamsen, FCS, USDA, Information 5, September 1957.

"Research in Agricultural Cooperation Problem Areas," FCS, USDA, Gen. Rept. 40, January 1958. (Formerly Misc. Rept. 176 issued July 1953.)

"Revista del Banco Nacional de Cuba," And III, Number 12, December 1957, Cuba.

"Revolving Fund Method of Financing Farmer Cooperatives," Helim H. Hulbert, Nelda Griffin, Kelsey B. Gardner, FCS, USDA, Gen. Rept. 41, March 1958.

"Sources of Livestock Market News in South Carolina," D. W. Bickley, South Carolina Agr. Expt. Sta., AE 129, October 1957.

"The Conservation Reserve Program of the Soil Bank Effects in Selected Areas, 1957," Farm Economics Research Division, USDA.

"The Economic Papers," Vol. II, No. 2, November 1957, The Department

of Applied Economics and Commerce, Patna University, Patna-5, India.

"Trends and Patterns in Levels of Living of Farm Families in the U. S.," Alvin L. Bertrand, AMS, USDA, Agr. Info. Bul. 181, February 1958.

"The Special Milk Program, Its Effect on Consumption in St. Louis and Los Angeles Schools," Kenneth E. Anderson, AMS, USDA, Mktg. Res. Rept. 209, January 1958.

"Use of Standard Exponential Yield Curves," D. B. Ibach, ARS, USDA, ARS 43-69, February 1958.

"World Grain Trade Statistics, (Exports by Source and Destination) 1956/57," Food and Agriculture Organization of the United Nations, Rome, November 1957.

BOOK REVIEWS

Farm Prices, Myth and Reality, Willard W. Cochrane. Minneapolis: University of Minnesota Press, 1958. Pp. vii, 186. $4.00.

In short, this book should be read in spite of its limitations, because it presents a widespread point of view in an articulate and delightful style. The economic image Cochrane presents of agriculture is a useful approximation, though oversimplified and, additionally, wrong at points. His discussion of valuation problems and of his values is interesting and will enable many persons to pin point some of their differences with the author in policy recommendations. Additionally, the pin pointing of valuation conflicts serves the more useful purpose of suggesting areas where the accumulation of quantitative knowledge would be helpful in enabling people to rank their values into more consistent patterns—both as members of groups and as single individuals.

The book, *Farm Prices,* would be more accurately titled if it were called *Alternative Programs for Commercial Agriculture.* My review of this book is based on the assumption its reason to be is to advocate, through the presentation of a limited number of alternatives, a specific program for commercial agriculture, rather than to analyze farm prices as such.

Cochrane reaches the conclusion that commercial farmers in the United States can and must unite to control production and price, and thus solve the farm income problem, if they are to avoid widespread losses and business failures, assuming the unwillingness of society to continue the treasury costs of income and price supports for agriculture. The technique he suggests is that of putting more teeth in production control, with the Sugar Act as a likely prototype. The public-utility approach is also suggested, but Cochrane does not advise the use of cooperatives as was tried in the '20s nor the use of AAA's as was tried in the '30s, '40s, and '50s. How was a conclusion of this sort reached? The brief is as follows:

(1) The agricultural income and uncertainty problems are real; they are the norm for agriculture. "They do not arise out of transitory phenomena; but are the logical and continuing consequences of chronic price instability in agriculture." (Chapter II)

(2) The supply and demand for all foods have elasticities approaching zero. These schedules shift, largely, as consequences of changes in technology and population, respectively. (Chapter III)

(3) Agriculture is on a "Treadmill" because the gains of technological change are quickly passed on to consumers. (Chapter V)

(4) The *non sequitur* of moving from the facts to policy recommendations is recognized. Cochrane therefore summarizes his values, which are presented as follows: (Chapter VI)

(a) "The foremost, the paramount value in my system of values is the Golden Rule—thou shalt do unto others as you would have them do unto you."

(b) "Another positive value of mine, but one far down the scale from the Golden Rule, is a high and rising material level of living for myself and others. . . ."

(c) "Like all people who take pride in our country, I value certain of our institutions highly. . . ."

(d) ". . . I am indifferent to the question of Government ownership and operation of productive resources."

In addition to the above positive values, the following are listed as things he objects to:

(a) "A more unequal distribution of income than we currently have in the United States."

(b) "A more rapid rate of technological advance in both the farm and nonfarm sectors than we now have, with the social adjustment and institutional changes that a more rapid rate of technological advance would entail."

(c) "An ideology and policies designed to move in the direction of an intense individualism on one hand, or the corporate state on the other." (Page 132)

(5) Blind policy alleys are listed under the headings of (a) The Free Market Approach, (b) The Flexible Price Support Approach, (c) The Farm Efficiency Approach, (d) The Fixed Price Support Approach and (e) The Domestic Food Consumption Approach. (Chapter VII) Each of these approaches end ". . . in a blind alley for one reason—too much production."[1] (Page 158)

(6) Cochrane, in agreement with, and by quoting, Benson, calls for "a new dimension in farm policy." Cochrane then poses two alternatives along with his answers. Alternative one is for all society to continue to underwrite the *money costs* of price and income supports to agriculture. If this choice is followed, which he considers unlikely but yet ". . . the rational approach to income protection for agriculture," a Brandow compensatory payments-type program is endorsed. A second alternative is then sought, apparently because under a Brandow type compensatory payments plan ". . . aggregate output would surge ahead of aggregate demand," and because ". . . it is something society will not choose to do." This alternative (Is it the "new dimension"?) is to control production *a la* Sugar Act, or possibly by the public-utility approach. The obstacle to be

[1] Cochrane can not intend this statement literally. For example, in the final paragraph of the book he states: ". . . commercial farmers are confronted with an inescapable choice: they can either choke off the rate of aggregate output expansion through widespread losses and business failure under the free market approach, or bridle the rate of aggregate output expansion by the widespread acceptance and use of production and marketing controls."

overcome in reaching the "new dimension" is suggested in the following words: "In other words, it is contended here that once the fog of the 'automatic-adjustment' myth is lifted, and farmers are able to realistically appraise the price-income-quantity consequences of this increasingly productive machine of which they are a part, they may want to place some effective production and marketing controls over that machine, . . . and thereby convert low incomes into high ones." (Chapter VIII) Thus he returns to the attractive subtitle of the book, *Myth and Reality,* and to the content of the first two chapters where Myth is the automatic adjuster "toward a golden mean" (page 3) and Reality is made up of "*wide and irregular swings in the farm price level . . . a continuum of commodity price variability, from almost none to extreme. . . .*" (Page 29)

Thus speaketh the man of Hobbes to the children of Locke—commercial farmers unite, control production and price and "convert low incomes into high ones."

In my opinion, Cochrane has reached a dead end in his aspirations for both the farmer and the nonfarmer. His quest of a dead end, both as a personal choice and as a cause to impose on others, seems to flow from his economic image of the world and his valuations. The evidence suggesting this conclusion deserves comment.

Cochrane, in his comments on aggregate supply and demand elasticities, tends to reason from the lower limits of usual estimates, rather than the other way around. Likewise, he reasons from expected shifts in supply and demand schedules that are a bit gloomy in terms of the difficulties of adjustment problems. For example, he does not consider the tendency of technological change to increase the elasticity of supply schedules.

Second, he suggests the existence of a much closer connection between supply restriction, price increases and increased net income than makes sense.

Third, he appears to really think restricting supply is feasible, as well as that it would increase net income over the long pull.

The crucial points in his list of values that play a part in his conclusion are several.

He states "on this rock (Golden Rule) all my ethical values rest, and on this rock my personal behavior, I would argue, should rest." This rock loses content and becomes but a method of stoning people, with a sense of righteousness, unless the other people hold values identical to the ones of the doer. May I use the following "bad example" to illustrate the point? I would have others serve me baked ham on Friday—yet, I know many who would not have this done to them. Cochrane, it should be pointed out, recognizes a problem in the existence of differing values, as well as ". . . certain inconsistencies—valuation conflicts—that show up around the edges . . ." of his picture.

Cochrane in his revolt against progress, ". . . the thesis of this Chapter;

the technological explosion, the technological monster, in American agriculture *requires* a new dimension in agricultural policy," positions himself against the trend of the last several hundred years, the thing that differentiates man from other animals and plants, and in my opinion the survival of the United States as we know it. His "new dimension" is to jump off the "Treadmill" under which the technological gains in agriculture are soon passed on to consumers and which also turns the dynamo of economic prgress, and to climb on the Treadmill of reduced output, higher prices, increased net income, increased costs, lower net income, increased restrictions on output, etc. This suggestion for policy is a bit less than inspiring to a person with my "perverted" sense of values that holds economic progress as good, the relative rate of which determines the survival value of western civilization, though survival is only a necessary condition for that which is good.

Rather than to end my review at this point, I will take this opportunity to dispell myth and plant our feet firmly in reality. Our return to reality shows that the world and the United States is in desperate need of speeding the rate of economic progress. This is evidenced by observing that much of the world is, at best, but a short step ahead of the Malthusian specter. In the United States this need must be met if we are to even partially succeed (1) in meeting the implied income demands of agriculture, labor and even school teachers, (2) in meeting the Soviet military threat and yet to maintain a balanced economy and (3) in fulfilling our duties, modestly defined, in foreign aid. The variables needing attention in present day United States, if economic progress is to be speeded, are three: (1) knowledge, (2) incentives to be more efficient and (3) more savings. At the present, the variable placing a ceiling on our rate of economic growth is an inadequate amount of savings, not only in agriculture, but in much of the entire economy. The proof of this requires an essay—not a paragraph in a book review. General measures to increase the supply of investable funds and to, at the same time, either increase or decrease the price level are available. Government needs only to buy its nonbank held debt and the securities of others with printing press money, by borrowing on the basis of nontransferable bonds from the banks, or if a lower price level is desired, by buying these securities with tax receipts. In this way an adequate amount of resources can be diverted to capital accumulation, the vehicle of economic progress, thus enabling us to use the technology we have been intelligent enough to develop, and to do it without detailed qualitative controls on individuals and firms. Matters of equity, that usually require 200 per cent of national income to solve, must not become the first policy consideration. If they do, we will likely get equity —complete equity in the grave.

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Linear Programming and Economic Analysis, Robert Dorfman, Paul A. Samuelson, and Robert M. Solow. New York-Toronto-London: McGraw-Hill Book Co., Inc., 1958. Pp. ix, 527. $10.00.

The book under review is an ambitious and skillfully executed undertaking. Its broad objective is to explain the relationship of activity analysis to traditional economic theory. The explanation is given in relatively elementary terms. Virtually all the mathematics used in the main body of the text is covered in a clearly presented 36 page appendix on matrix algebra. Since activity analysis is compared to traditional economic theory, it is necessary for the authors to describe traditional theory. This descriptive material is of great value in that it approaches the subject from a different point of view than is customary.

The authors' conclusions concerning the comparison of activity analysis and conventional theory are summarized in the following selected quotations.

"Linear programming *is* marginal analysis, appropriately tailored to the case of a finite number of activities. 'Traditional' marginal analysis is tailored to the case of a differentiable production function." (footnote 1, p. 133)

"By considering increasing numbers of processes, linear programming can be made to approach the continuous case as closely as may be desired." (p. 141)

"Carlson's production function (i.e., the conventional one) cannot even be written down until a programming problem has been solved." (p. 202)

"We see, thus, that the production function as conventionally defined summarizes the solutions to the underlying programming problems for various values of the variable factors." (p. 203)

"The numerous restraints and the inequality signs that clutter up a programming problem are absent from the conventional [smooth production function] formulation, not because they are inapplicable, but because it is assumed that they have already been handled." (p. 203)

"It is only when we insist on infinitesimal substitution, on continuously varying marginal rates of transformation, on sensitivity of factor proportions to all price variations no matter how slight, that we have to give up the polygonal [efficiency] frontier for the neoclassical smooth curve." (p. 349)

"If a set of empirical facts can be idealized by either of the two theories of production, it can also be idealized by the other." (p. 366)

The reviewer's conclusion is that the authors made a very good case for their arguments. Their forceful argument should do much to overcome opposition in some quarters of our profession to the possibilities of linear programming. They do a particularally good job of explaining the true nature of the linear restraint in linear programming. This explanation is in a chapter devoted to nonlinear programming, or "general programming." Linear programming is shown to fail to adequately represent only those situations in which the objective (i.e. value weighting) function is nonlinear. Since this arises only in those circumstances in which output influences price, most agricultural problems relating to analysis of indi-

vidual firms can be handled by linear programming with the same logical precision as is possible with marginal analysis.

The only potentially important exception to the universal applicability of linear programming analysis to problems of firms in competitive markets is that in which increasing returns to scale exist.[1] That this situation would arise in the analysis of agricultural firms under competitive markets appears very unlikely, thus, the exception appears very unimportant.

The authors demonstrate very effectively that the case of diminishing returns—either marginal to an input or to scale—can be handled by linear programming under competitive output markets. Here linear programming appears clearly to score a mark above traditional marginal analysis, since with programming neither the shape nor the level of the production function is required. (Of course, if this information is available, linear programming can effectively use it.) Through the use of linear programming analysis we could be spared attempts to answer many basically unanswerable questions relating to which of several logically alternative functions is "best" by how much and by which criteria.

Another substantial contribution of this work is the presentation of a critical analysis of Leontief's static input-output theory, von Neumann's theory of games, and three models of capital and investment theory. These latter are the Leontief dynamic input-output, the von Neumann and the neoclassical models. The primary reason for including these other tools of "linear economics" was to compare them to linear programming and to establish linear programming as "the core of linear economics." The comparisons are interesting but the exposition of these theories in such lucid form is probably a more substantial contribution. All of these models reduce to a linear programming model, or a linear programming model can be developed to express the same logic—usually to advantage. In the case of the von Neumann game theory, however, the authors point out that linear programming problems may, on occasion, be stated to advantage in the form employed in the game theory problems.

The authors exercise particular care in demonstrating weaknesses of both the static and dynamic Leontief models *vis a vis* the linear programming model. Of the former they say, "The theory of input-output [Leontief's] can also be regarded as a peculiarly simple form of linear programming. . . ." (p. 204) Of his dynamic model they say, ". . . the Leontief dynamic system [is] . . . causally indeterminate and incom-

[1] Of course it is important here, as elsewhere, to distinguish between returns to scale and change in efficiency with variation in input proportions. Increasing returns to scale exist if, for example, a doubling of *all* inputs more than doubles output. The problems of firms having this kind of output response cannot be handled conveniently by linear programming. It can handle, however, problems of variable proportions. Empirical observations from agriculture of change in efficiency with change in output can generally be interpreted as change in proportions of inputs.

plete. . . ." (p. 298) The authors do not state that at least some of the simplicity and incompleteness of the Leontief model represents a compromise made to gain operational feasibility. However, many of their points are very well taken and those interested in input-output models for agriculture will find much of value in their discussion.

A linear programming model was demonstrated to be equivalent or superior to the Walras-Cassel general equilibrium model in all respects. Ease of proof of a unique solution to the system, if such exists, is one of the important advantages of the linear programming statement. A linear programming model was used to prove certain postulates of welfare economics with greater facility than is possible with the traditional models.

The dynamic linear model presented by the authors appears to have some possibility of fruitful application to both firm and industry problems in agriculture.

The description of formulation and solution of linear programming problems was one of the least well-done parts of the book. Compared to the exposition of game theory, for example, it was needlessly involved. Much better expositions of the technique are available to the beginning agricultural students of the subject.[2] The discussion of "general" or nonlinear programming, on the other hand, is the least complicated presentation known to the reviewer.

The following passage seemed well-directed to those of us in agricultural economics who have devoted efforts toward developing "cooperative" research efforts with technical production specialists.

> "The production function is a description of the technological conditions of production, and the economist takes no direct responsibility for ascertaining it. Instead he regards it as falling within the purview of the technologist or engineer. But there seems to have been a misunderstanding somewhere because the technologists do not take responsibility for production functions either. They regard the production function as an economist's concept, and, as a matter of history, nearly all the production functions that have actually been derived are the work of economists rather than of engineers." (p. 131)

The authors offer the hope that if we choose linear programming as our analytical vehicle and substitute the idea of processes, or "ways of doing things," for that of the continuous production function we will improve our communication with the technical specialist. I believe this approach deserves a try.

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[2] *Cf.* James N. Boles. "Linear Programming and Farm Management Analysis," *Journal of Farm Economics*, Vol. 37, February 1955, pp. 1-24, or Earl O. Heady. "Simplified Presentation and Logical Aspects of Linear Programming Technique" *Journal of Farm Economics*, Vol. 36, December 1954, pp. 1035-1048.

The Federal Lands: Their Use and Management, Marion Clawson and Burnell Held. Baltimore: Published for Resources for the Future, Inc., Johns Hopkins Press, 1957. Pp. xxi, 501. $8.50.

Approximately 20 per cent of the total land area of the United States is owned—and managed—by units of the federal government. These federal lands are currently producing annual revenues in excess of $350 million. The assumptions and evidence presented by Clawson and Held indicate that the future will bring increasing importance of the federal lands in the total resource picture. Because management of these lands has become big business, the authors raise two questions central to their entire study: (1) Has administration of the federal lands kept pace with the rest of our economy? (2) Do alternative methods of management exist that are better adapted to the present and probable future demands on these lands?

The study is divided into an introduction, six chapters, and legal and statistical appendices. The introduction and first chapter define the scope of the study and trace the evolution of the present status of federal lands in our economy. These sections are brief and to the point. The reader interested in greater historic detail is referred to standard sources. This reviewer takes exception, however, to one part of this section. The apparent desire to coin a new phrase led to the definition of the "Era of Intensive Management" to describe the period since World War II. To be sure, the increased expenditure of capital and labor has brought about more intensive "cultivation" of our federal lands—but so has the increased use of federal lands by the public at large. This may be associated with many different desires on the part of those who make decisions with respect to management of federal lands: approximate an optimum state of conservation, increase attendance at National Parks, prevent forest fires, improve insect and disease control, improve grazing conditions, etc. The mere ability to implement these desires does not create a new type of management. The attainment of *better* management does not seem to require the definition of a new era of public land policy—particularly one that has questionable implications.

Chapter 2 illustrates and documents past, present, and probable future uses of our federal lands. The authors discuss the many management problems that face those who make decisions with respect to development and use of the federal lands. They make skillful use of available statistics on federal lands in this chapter as well as throughout the entire book. They are quick to point out gaps in available data and the problems these create. Their constant plea—and a well taken one—is for more comprehensive and complete statistics for federal lands.

The third chapter details and examines the processes by which policy is set and decisions made with respect to federal land management. For

the most part, it is a review of elementary political science detailing characteristics that apply to almost any phase of federal policy and action programs: widespread public interest and pressure, legislative and budget-appropriation-allocation processes, diffusion of authority and responsibility, and the inevitable "chain-of-command" with its inherent weaknesses. The authors argue that there is need for revision in the system if efficient management decisions relating to the use of federal lands are to be made.

Chapter 4 discusses and analyzes the wide variety of investment and pricing arrangements that exist for the products of federal lands. Chapter 5 is a discussion of revenues and expenditures relating to federal lands. These two closely related chapters have much the same theme—data are insufficient and organization inadequate to permit management decisions that will bring federal land resources up to optimum productivity. For some products, economic pricing principles are followed, but more often than not, political considerations dominate, yielding revenues below the optimum level. Investment practices and expenditures, dependent on budget appropriations, tend to be lower for federal lands than private practices would dictate. Some may argue that such a comparison is against inappropriate criteria. But measuring pricing and investment practices against strict economic models or against less precise general welfare considerations, the authors still conclude that current pricing and investment practices keep the entirety of federal land resources at less than optimum productivity.

Previous and current analysis of revenue and expenditure data has been largely restricted to partial evaluation by the separate divisions of the federal government that are responsible for the federal lands. It is impossible to identify or measure changes in revenue associated with changes in expenditures for the total of the federal land resources and very difficult to do this even for small segments of the total. Clawson and Held maintain that without improved data and an integrated restructuring of the decision-making units, the federal land resources cannot be managed anywhere near an optimum level—and this regardless of the criteria used to define optimum.

The study concludes with a final chapter devoted to several sets of alternative suggestions for reorganization of the entire process of federal land management. These suggestions range from the establishment of a Federal Land Corporation to minimum of change from the present organization, including perhaps a federal land review board. It is apparent that the authors believe a Federal Land Corporation would provide the best vehicle for achieving optimum management for the federal land resources; it is equally apparent they recognize such a solution to be unattainable—at least in the near future. In spite of this, many fruitful and

worthwhile reorganizational possibilities are detailed with the hope that at least some may be adopted in the future. Clawson and Held recognize and discuss the difficulties to be encountered in any future reorganization of the bureaus and departments responsible for federal land management. But suggestions are carefully set forth and their arguments well supported so that if steps are taken in line with their suggestions, a better level of management of federal lands could be achieved.

The only major negative comment this reviewer has concerning the book is that the authors seem to find the solution to federal land use and management problems solely in reorganization of the structure. Given their basic assumption that acreage in federal land will remain relatively constant in the future, perhaps their solution is all that is necessary. But it seems highly likely that extensive reorganization of the federal land management structure would bring forth specific responses from the non-federal land resources. Clawson and Held could have strengthened their study if they had included a final chapter on the possible impact major reorganizations in federal land agencies and bureaus would have on total land resources in the United States. Important as federal land is to the total economy, private ownership is predominant. Any serious suggestions for changes in federal land practices, programs, or policies would be more helpful if at the same time analysis were made of the probable extended impact of the suggested changes.

The Federal Lands: Their Use and Management is a book that any student of natural resources economics may study to his profit and interest. Facts and data relating to federal lands are presented in this one source—including a useful 10 page legal appendix and an excellent 73 page statistical appendix—that formerly could be obtained only from exhaustive study of multitudinous sources. The book is timely and up-to-date including good discussions of the very recent use and management problems created by development of the submerged off-shore continental lands. Even the reader who disagrees with some of the suggestions made by the authors must agree that this book will provide much useful food for thought for those faced with federal land management decisions as the use and development of the federal lands becomes more important through time.

Marion Clawson is currently director of the land use and management research program for Resources for the Future. He also served for several years as director of the Bureau of Land Management in the United States Department of the Interior. Burnell Held is a research associate with Resources for the Future.

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River Basin Development. Law and Contemporary Problems: A quarterly published by Duke University School of Law. 22:155-322. Spring 1957. Single copies $2.00.

Water Resources. Law and Contemporary Problems: A quarterly published by Duke University School of Law. 22:323-537. Summer 1957. Single copies $2.00.

These two collections of articles on river-basin development were prepared at the request of the editor of the quarterly.

Economics, law, engineering, and politics are covered in the river-basin publication. Contents of the papers are suggested by such terms as perspective, economic dynamics, social consequences, evaluation, politics, and water rights. Most readers should find the stated goal of this symposium, to stimulate serious reflections on problems of river-basin development, accomplished. The authors are highly regarded authorities in their respective fields and subjects. Obviously, only brief and partial treatments of so many subjects are feasible within the scope of a single quarterly.

The editor observes that only recently have river basins been recognized as appropriate units for planning efficient management of water resources. The papers, in their descriptions of existing and past programs, raise some question as to whether this general recognition prevails. Certainly, agreement as to means of accomplishment is not unanimous. In most instances, the papers do not offer alternative solutions to the problems posed.

The symposium and publication on water resources are directed largely to a consideration of means and programs. Papers on various federal programs are included. The roles of federal, state, and local governments and of private individuals and groups of individuals are analyzed and discussed. More specifically, the articles cover federalism, TVA, conservancy districts, small watershed programs, private enterprise, and national policy and administration. The stated objective of the symposium is development of a sound water resources program through an enlightened public in a democratic society. A logical first step is knowledge and evaluation of existing programs. The publication contributes substantially to this objective through its papers by leading economists and political scientists. A contribution is made toward an evaluation of alternative programs and toward integration of related but basically different approaches to development of water resources.

The question of private versus public development, and for larger developments, federal versus state and local, hinges in large measure on multiple-purpose versus single-purpose projects. Market demand has not brought forth private investment for several purposes of water-resource development which are believed to be desirable. Greater emphasis on

this point would have been appropriate in the articles under review.

The conflicts and methods of the several federal agencies gave rise to considerable discussion in both series of articles. In some instances it was implied that "valley authorities" would resolve these problems. It appears, however, that valley authorities over the country are likely to generate similar problems.

The titles of the two issues imply somewhat different coverage. But the basic subject is the same; it is the point of emphasis that differs. The water resources issue might be more appropriately called the political aspects of river-basin development issue. The issue titled *River Basin Development* is concerned more with basic physical, economic, and institutional aspects.

Economists will find these two issues important reference sources on development of river basin. It should be recognized that essentially the same materials and subjects are covered elsewhere in published literature by many of these authors and others. The reader must look elsewhere also for several relevant viewpoints on water-resource development.

CLYDE E. STEWART

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Federal Lending and Loan Insurance, R. J. Saulnier, Harold G. Halcrow, and Neil H. Jacoby. A Study by the National Bureau of Economic Research, New York. Princeton: Princeton University Press, 1958. Pp. xxx, 566. $12.00.

This is a statistical and analytical portrayal of the development and current position (in 1953) of the far-flung activities of the federal government in the credit granting and loan insuring business. It was written to improve public understanding of these important federal activities which have grown up without adequate documentation or appraisal. The National Bureau of Economic Research has added another important volume to its now sizable collection of postwar financial studies.

The statistics are presented according to the fields to which they refer, mainly agriculture, housing, and business and according to whether the operative agency is a direct credit agency of the federal government, or a "federally sponsored agency"—that is, one with some sort of financial or administrative tie to the government even though it may use no federal funds. Loan insurance and guarantees, which by 1953 far overshadowed the loan granting activities, were assigned to the direct credit agencies. With such a wide range of programs to cover, the difficulty of summarizing these federal activities and drawing conclusions about them was of course very great.

In addition to presenting data on outstanding credit at year-end dates, the authors gathered together the equally significant and harder to obtain

data on new credit extended. Information on losses was also obtained to permit some judgment of the over-all cost of programs. Altogether this collection of data has broken much new ground.

The most important effects of government credit activities in each of the three fields have been to modify "the markets, practices, and economic functions of the private financial system in profound and enduring ways." Thus in agriculture, according to the authors, private lenders have been stimulated to lower interest rates, increase loan sizes, and lengthen loan maturities. In farm mortgage lending, undoubtedly there has been marked lengthening of maturities. In the nonmortgage area, the available data are rather inadequate, but it is evident that, despite competitive pressures and farm needs, a large part of lending for farm machinery and other capital improvements is still on a short-term renewal basis. Actually, competitive pressures to lengthen maturities have not been strong; it is only since 1955 that loans of the federally sponsored production credit associations have been made with scheduled maturities beyond one year, even though the Intermediate Credit Banks were established in 1923.

Another conclusion reached by the authors is that "the federal government has had an unfavorable credit experience when it has attempted to supply credit . . . to business firms and farm enterprises unable . . . to find financing on reasonable terms through private lenders." While some of the Farmers Home Administration loan programs resulted in high loss figures, for the most part these were programs specifically designed to meet emergency needs and high losses were anticipated. The major nonemergency lending programs of the agency, both mortgage and nonmortgage, have sustained what many would regard as only moderate losses.

Are Commodity Credit Corporation price support loans to be regarded as loans or not? This thorny question might well have been explored more fully. The explanation given for including them here as loans is that "the amounts involved were appreciable in certain years." After an explanation of the way in which CCC loans are included in the over-all statistics, it then becomes evident that except for three charts, CCC loans are not included in any of the compilations for the agricultural sector or for the over-all economy.

For the general reader the part of the book dealing with aggregative relationships is the most interesting. It is also the most controversial. One of the relationships examined is between federal lending activities and monetary policies in terms of their contributions to economic stability over the years from 1917 to 1953. Any such study is bound to be a large undertaking, partly because conditions have varied so widely over this period, and partly because no single measure is adequate to portray very

satisfactorily any one of the three things being compared—federal lending policy, monetary policy and stabilization policy.

The authors suggest one important uncertainty with regard to the use of any measure—such as GNP or the National Bureau cycles—as a reference standard for evaluating counter-cyclical action when they show one comparison in which the first year of recovery is regarded as a time for counter-cyclical action, and another comparison in which it is regarded as a time for pro-cyclical action. The importance of distinguishing between periods of war and peace is indicated by the showing of separate comparisons including and excluding war years. Difficulties involved in using any single measure are also noted elsewhere.

Alternative comparisons suggested at various points all throw some light on the complexity of the appraisal problem posed here—but do they go far enough? How is growth in the economy provided for in a scheme where increases in GNP are generally regarded as requiring counter-cyclical action? And, from the point of view of stabilization, should federal lending policies in each of several diverse fields, including agriculture and housing, be geared wholly to the general situation, or should they be varied to a degree when developments in a particular sector run sharply counter to those in the economy as a whole? Discussion of such questions and of questions relating to various measures of monetary policy would have helped to illuminate the very difficult problems in this whole field.

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* The views expressed are the personal ones of the author and in no way reflect the views of the Board.

Toward Responsible Government: An Economic Appraisal of Federal Investment in Water Resources Programs, Edward F. Renshaw. Chicago: Idyia Press, 1957. Pp. xii, 164.

The book presents the most complete economic analysis of Government investment in water resources development thus far published. Part I examines the economic arguments for the various types of projects in river basin development which receive public investment funds. Part II considers assessment of benefits of irrigation.

As the title suggests, the book carries a torch. It endeavors to alert the Congress and the public generally to the social costs of uneconomic investment in water resources projects. These costs are measured in terms of alternative public investments of more pressing importance which are forgone. "Given . . . the necessity of making dramatic changes in appropriations in order to maintain our national defenses, to prepare ourselves for the age of missiles and space explorations, and to lay the foundation

for an era of unparalleled scientific and technical competition on an international level," the author, states, "scrutiny of expenditure policies in water resources development is increasingly apropos."

The author analyzes each type of expected benefit and finds little to justify them. Reclamation is likely to be unsound since a scarcity of food in the next 20 years is improbable. Even with a scarcity, reclamation could not supply over 10 per cent of the additional food needed by that date, and the needs could be supplied more economically and efficiently through investment in "research and extension, removal of tariff barriers on food stuff, and private investment in land rehabilitation, drainage, and clearing."

Power developments will likewise prove an uneconomic application of public investment funds, because benefit computations usually disregard marginal cost pricing. This leads to a redistribution of income in favor of power users. The author believes also that steam plants and atomic energy plants will replace water power plants as an economical source of energy, because of rapid technological advances in these fields.

Flood control installations do little to control flood damage. Navigation benefits as calculated by the Corps of Engineers are overestimated. The author maintains, however, that "the most important losses stemming from the Federal navigation program may not be the direct losses allocable to navigation investment but the fact that alleged navigation benefits can be used to justify directly or indirectly equally wasteful investment in other features of multi-purpose projects." Small watershed project benefits are estimated on the basis of increases in land value. The author agrees with this method of appraising benefits but criticizes the Soil Conservation Service for underestimating costs and using a 2½ rather than a 5 per cent interest rate.

In Part II the author develops his thesis that benefit analysis in irrigation should be confined to the calculation of expected increases in land values alone. An ex post analysis of 34 projects on this basis using an interest rate of 4.1 per cent indicated that only eight had a ratio of benefits to costs greater than one.

In the final chapter, the author presents some multiple regression equations which he feels would provide a more refined method of calculating benefits from irrigation based on land value increases. These equations could be computed easily and quickly once the cropping pattern of the proposed irrigation project is known.

In the opinion of this reviewer, the book loses much of its force by the author's assumption of the role of prosecutor with water resources investments as defendant before the bar of justice. In his eagerness to obliterate every economic argument put forth by the defense, the author introduces some inconsistencies and errors of his own.

In the first place he considers only one macro-economic model, that of a full employment static equilibrium economy. Most of the economic arguments against water resources investments stem from the rigidity of the model. Had the author introduced or even considered a variation from these static assumptions many of his conclusions would not have followed. Only under full employment assumptions can one conclude that any investment which yields a rate of return over cost of less than the average interest rate will result in a redistribution of income. Only under such assumptions also will one reason that public investments in other areas are being restricted by competing ones. Only under such assumptions likewise can one believe that secondary benefits have no value unless they can be shown to yield returns greater than those derived from the general average of all investments.

The difficulty with these static assumptions is that they are tautological. If it is assumed that all loanable funds would be invested at the average rate of interest if not otherwise employed by the government, it must be concluded that all federal investments in income-producing projects are uneconomical. The only exceptions to this rule would be that private investors would not undertake the investment because (1) the amount of investment is too large for private enterprise, or (2) it will take too long a time to yield its returns, or (3) the government is shrewder in uncovering investment opportunities than are private investors. These conditions could be expected to occur today only infrequently. With his conclusions thus in essence assumed, one may question the value of the elaborate research that went into the study.

This type of reasoning may have harmful effects on public investments during periods of less than full employment. Presumably only those government investments can be justified in which market values either do not arise, or can not be estimated with any precision, as in the case of defense, guided missiles, space explorations, education, etc. This type of investment presumably is to be preferred over investments which yield some economic return but less than that required by the going rate of interest in the private economy.

Several inconsistencies have crept into the analysis. The author laments the competition of water resources projects with defense, yet spends a chapter decrying the inclusion of income from the growing of sugar beets as a benefit in water resources projects. The tariff and quota on sugar beets have been defended always on the basis of self sufficiency, a defense measure. He objects to the methods of computing power benefits because they fail to consider marginal cost pricing. In his analysis of benefits from supplemental irrigation projects, however, he ignores entirely the marginal value productivity of these projects. He assumes they would supply water that would lead to diminishing crop returns, when as a matter of fact

additional supplemental irrigation projects supply the water that brings the greatest crop yields. Their marginal benefits consequently are significantly greater than their average benefits.

The author argues that research and extension can provide for agricultural needs more economically than can new irrigated land. This statement denies the possibility of diminishing returns to investments of this nature. History would contradict this conclusion. If it were true, densely populated areas such as England and the Netherlands could profitably employ such methods today.

This quick summary does not do justice to the research and thought that went into the writing of this book. It presents a formidable case against public investment in water resources projects. It is recommended as required reading for all students of this subject.

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Economic Development. Charles P. Kindleberger. New York: McGraw-Hill Book Company, Inc., 1958. Pp. xiii, 325. $6.50.

This book divides logically into three parts: (1) elements in the process of growth, (2) domestic issues in development, and 3) international issues in development. The focus is on underdeveloped countries.

To this reviewer, the strength of the treatise lies in the synthesis of the accumulated economic, social and political ideas about the process of economic development and in the breadth of viewpoint taken in describing economic development. Some important policy conclusions emerge from the concepts and ideas, but, in general, the reader is left with the questions instead of the answers to policy issues. This emphasis in policy was intentional; present knowledge is inadequate for prescribing how a country can break out of a stable equilibrium in poverty into a process of interacting and cumulative development. ". . . Theories abound; opportunities for rigorous testing are limited." (p. 309)

Those with expectations of the long-sought general theory of economic development will be disappointed in this book. However, those appreciative of the difficulties of this attainment, and instead, seek a treatise which critically evaluates existing theories, combined with ideas on *what* is relevant and *what* has evolved and currently exists, will be delighted with this book. An appeal to the facts at this stage in our thinking is a possible route toward further progress in the construction of theory in economic development.

Kindleberger stated the viewpoint taken in the book as follows: ". . . Since the various ingredients can substitute for one another to a considerable extent, and since the process of development has at various times been led by one or another among the ingredients and elements, we

refrain from ranking land, capital, labor, technology, scale and transformation as causes and effects, respectively, or in order of importance in the growth process. . . ." (p. 14) In general, those who have pursued the practice of choosing one variable in the process as the hero of an analytical scheme to explain development have overlooked the substitution possibilities. Kindleberger found "empirical validity" for the major theories and concepts of growth previously developed as partial explanations or as necessary conditions for the growth process.

Other than the placing of old ideas and concepts in a new perspective, Kindleberger gave greater emphasis to the social aspects of the subject and to the role of market growth than found in most treatments. Social considerations were handled as elements of the land and labor variables. Growth of markets was handled as an aspect of the scale and specialization conditions in production and as a condition in transformation, or the redistribution of manpower among industries.

Many observations were assembled to document and support the ideas presented. Some of the observations were presented graphically as scatter diagrams depicting relations of independent variables, or supposed conditions in growth, to per capita income of the different countries. Significant or nonsignificant correlations were inferred or implied from the degree of "goodness of fit" determined by visual inspection of the graphs. This method of demonstrating "empirical validity" of the variables as necessary accompaniments of growth is a major weakness of the analysis. This book should rank high among the possibilities for texts in courses on economic development at the intermediate level. It would be a valuable addition to the personal libraries of economists and others with interests or responsibilities in growth of underdeveloped countries.

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The Agricultural Register, The Agricultural Economics Research Institute of the University of Oxford, Bedford, England: The Sidney Press, Ltd., 1957. Pp. viii, 234. 21 S.

This volume was written to give a concise and impartial account of the present-day position of British agricultural policy. To achieve this objective the authors seek to show the record of action taken concerning policy. They present information on such topics as marketing, prices, imports, labor, land, capital, and inputs in the United Kingdom. This study is the product of a review of a formidable quantity of material surpassing the considerable quantity reviewed for the 1930's which was published in *The Agricultural Register* for 1938-39.

The authors point out that more changes occurred in 1957 than in any other year since 1947 with respect to formulation of government ob-

jectives and their implementation. Two changes as provided by the Agricultural Act of 1957 were of particular note. The first was the removal of uncertainty of future price policy for agriculture; the second was the emphasis given to production grants as distinct from price subsidies.

Over the years the main cause giving rise to doubt in farmers' minds had been the conditions of the "Annual Review," which to many meant the possibility of an annual upheaval in policy. The new Act largely removed this doubt by providing long-term assurances with regard to price policy. The Act specified that guaranteed prices for each individual commodity determined at an Annual Review must be not less than 96 per cent of the guaranteed price determined at the previous Annual Review; guaranteed prices for livestock and livestock products were not to be reduced by more than 9 per cent in any three years; and the total value of the agricultural guarantees (price guarantees plus production grants) must be maintained each year at not less than 97½ per cent of the total value of the guarantees in the preceding year, after adjustment for changes in costs on review commodities since the previous Annual Review.

Expansion of net output to 60 per cent above pre-war has been the major objective of British production policy as regards agriculture, according to the authors. The government aimed at the achievement of this objective by means of an increase in the production of beef, mutton and lamb, and an improvement in crop yields, ley farming (grassland farming), grass management and the use of concentrated feeding-stuffs. The *Register* indicates that net output in 1956-57 was 59 per cent above prewar. Maintenance of expansion of net output in 1957-58 was to be sought primarily by reliance on a large arable acreage with more emphasis on feed crops, increased dependence on home-produced resources for the maintenance of a large livestock population and the production of more good quality beef and lamb.

To achieve the desired resource use to fulfill production needs, guaranteed prices were set for fat cattle, fat sheep, fat pigs, hen eggs, duck eggs, fleece wool, milk, wheat, barley, oats, rye, potatoes and sugar beets. Subsidy payments in implementation of these price guarantees and production grants in 1956-57 were estimated at £245 million ($686 million). In the same year, the total value of guarantees, excluding production grants, was estimated at £1,127 million ($3,156 million), whereas total farm sales, excluding horticultural products, amounted to £1,243 million ($3,380 million). Thus, continue the authors, approximately 90 per cent of agricultural output, sold for personal consumption or industrial purposes, was covered by government guarantees in 1956-57. There are no price guarantees for fruits and vegetables except potatoes. Protection, however, is provided to home producers by a seasonal tariff. The government does not use price guarantees for horticultural produce because it is subject

to greater fluctuation in supply and demand than is other produce.

To supplement home production, Britain must rely on imports of food; she remains the world's largest importer of food. The authors also point out that the National Farmers' Union maintained that more was to be gained by adhering to Commonwealth trade arrangements than by joining the European Common Market and Free Trade Area with respect to agricultural trade. Over half of British exports went to the Commonwealth in 1956, compared with 13½ per cent to the six Common Market countries and 14½ per cent to the other O.E.E.C. (Organization for European Economic Cooperation) countries including the Irish Republic.

The fourth round of multilateral tariff negotiations under the G.A.T.T. was concluded in May 1956. Considerations of G.A.T.T. (General Agreement on Tariffs and Trade) affecting agriculture, the authors point out, were duly considered with the advice and counsel of the Farmers' Unions. The Unions pointed out the paucity of existing tariff protection for agriculture, and stressed the increased importance of tariffs in view of the growing liberalization of trade. Great stress was laid on the importance of adequate import regulation in the case of horticultural products.

The second important change in 1957 with respect to formulation of government objectives and their implementation was the emphasis given to production grants as distinct from price subsidies. This underlined the growing attention of the government to problems connected directly with production rather than indirectly by way of prices and incomes. The government's farm improvement scheme, embodied in Part II of the Agricultural Act of 1957, sought to eliminate inadequate or out-of-date farm buildings or other fixed permanent equipment. Modernization, it was thought, seemed to offer the best way of making an effective contribution towards lowering production costs.

Most of the subsidies arising under the government price guarantees are related to various commodities and their production objectives; they affect the farmers' returns from sales of the produced goods after they have left the farm. In order to produce them, however, the farmer needs working capital, and in some cases also fixed capital. The government provides the farmer with a number of grants for this purpose. These include a plowing-up subsidy for grassland, a fertilizer subsidy, a marginal production scheme to aid small farmers to become economic operators, herd testing for tuberculosis, grants for field drainage and water supply, improvements in livestock breeding, eradication of bracken (defined by Webster as a thicket or brushwood) on pastoral land, loans to crofters (small tenants) and silo subsidies.

A breakdown of estimated farm expenses in the United Kingdom shows that feedingstuffs accounted for slightly less than a third of the aggregate value of farm expenses in 1956-57; labor ranked second in significance

with one-fourth; and machinery accounted for 17 per cent of the aggregate value. Although representing only 7 per cent of the aggregate value of farm expenses in 1956-57, fertilizer use has shown a rapid increase since 1939. Increased mechanization (and electrification) of farms has also continued. British farming, according to the authors, is today one of the most highly mechanized in the world. Despite this trend, the total of workers in December 1956 was slightly above the 737.1 thousand reported for December 1955; there was a decrease, however, of regular full-time workers from 570.1 thousand to 555.1 thousand. The latter are entitled to receive a statutory minimum weekly wage under the Agricultural Wages Act of 1948.

In conclusion, this volume is a convenient reference, particularly for those intimately concerned with British agriculture. The reviewer recommends it as a useful volume for those who deal with foreign trade as well as those who develop agricultural policy. We need a similar *Register* for American agriculture.

ROBERT L. TONTZ

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Collectivization of Agriculture in Eastern Europe, Irwin T. Sanders, *et al.* (Eds.), Louisville: University of Kentucky Press, 1958. Pp. x, 214. $5.00.

In spring 1955, the University of Kentucky and the Ford Foundation brought together specialists in Eastern European agriculture for a campus conference. Papers that were prepared for this occasion are assembled in the reviewed volume.

The first three chapters establish the general setting: 1) historical analysis of the role of Eastern Europe in political affairs of the world, 2) "peasantism" as an anthropological and sociological phenomenon, and 3) collectivization of agriculture as an element of Soviet strategy.

The core of the book is made up of chapters 4 through 7, which are the basic seminar papers on collectivization in individual satellites (Bulgaria, Czechoslovakia and Poland, Hungary and Romania, and Yugoslavia) plus summaries of discussions that followed these presentations.

Four appendixes deal with: a) Marxist population doctrine, b) mechanization of agriculture in the Balkans, c) enumeration of crucial attributes of "peasantism" and d) a Who's Who of seminar participants.

The basic papers are generally descriptive in nature. The essay on Czechoslovakia and Poland is analytical. It was written by Ernest Koenig, economist with the Foreign Agricultural Service of the U. S. Department of Agriculture. From the professional viewpoint his contribution is by far the most stimulating.

Koenig accepts the thesis that collectivization has been adopted primarily because such a form of farm enterprise makes it easier for the

government to control and collect agricultural surpluses that are needed in economic development. In other words, collectivization is a method of forcing peasants to finance rapid industrialization.

A parallel thesis has to do with economies of scale in agriculture. Postwar land reforms have split up many large estates into inefficient small farms. As far as the Communists are concerned, the necessary land consolidation can only be done by means of collectivization. Koenig finds that "economic consequences of collectivization cannot be other than negative" (p. 109). Tremendus economic and social pressure is exerted on the private sector still representing the majority of all farms. It takes the form of unreasonably high product delivery quotas to the state at virtually confiscatory prices. This is combined with little or no access to fertilizers and other "external" means of production.

Such an institutional setup could only be justified if losses in production arising during the formative period could be compensated for by later superior achievements. Koenig points out that this has so far not been the case. He brings together fascinating evidence showing that with the possible exception of grain production, the material achievements of collectives fall short of private farmers. He concludes that collectivization has "contributed neither to agricultural progress nor to the well-being of peasantry . . . the social effort and labor devoted to this enterprise appear largely wasted." (p. 120).

Koenig's analysis is good as far as it goes, but it does not go far enough. Data showing stagnation of the aggregate agricultural production should have been matched with statistics on output per unit of labor. This, I believe, would have shown increases in labor productivity. With the tremendous exodus of youth from agriculture it could hardly be otherwise. So, if one considers the contribution made by satellite agriculture to the industrial labor force, collectivization would probably no longer look like a miserable failure. In fact, in terms of year-to-year increases of the Gross National Product, satellite economies are not doing so badly. The net capital investment, expressed as per cent of G.N.P. is outright impressive. With a higher rate of growth, it is merely a question of time before Russia and her satellites catch up with the Western democracies.

This achievement is timidly acknowledged by E. O. Stillman in his paper on Bulgaria. He points out that "Communist society . . . for all its massive strains and tensions . . . is extraordinarily stable. It has survived in the Soviet Union for 38 years, surmounting ordeals which led its warmest admirers, as well as critics to prophesy its imminent dissolution. The postwar history of Eastern Europe is remarkable less for chronic malfunctioning of the system imposed by the Soviets than for the ability of the satellite regime to maintain their rule over sullen and hostile populations for better than 10 years." This excellent statement, buried obscurely on

page 87, should have been carried as the theme of each and every chapter.

A well-balanced presentation that is published in the year 1 P.S. (Post-Sputnik) should hand the Communists our reluctant compliment to the effect that, somehow, there is terrible efficiency in their ruthlessness. As far as I am concerned, the book has failed in this respect. True, it is filled with all kinds of interesting pieces of selected information. Yet, the data is mostly of the adverse kind. It inevitably creates the impression of overall hopeless inferiority of the Soviet system in general, collectivization of agriculture in particular. This type of presentation will not do in 1958.

Finally, a few minor complaints about the arrangement of the book. These should be laid at the doorstep of the editor:

a) There is altogether too much overlapping—a frequent, yet avoidable shortcoming of such symposia.

b) George Washington's advice ,"Let your discourse with men of business be short and comprehensive," was disregarded. The subject matter of a couple of oppressively long seminar discussions, supposedly edited by rapporteurs so as to "avoid repetition of details," should have been incorporated into the original background papers.

c) Lengthy quotations of official speeches, statutes and bylaws belong in the footnotes, and not the text.

d) Most footnotes refer to original sources in East European languages. It would have been helpful to provide an index to some of the excellent current English references.

All in all, agricultural economists will find this a useful assortment of information about East European farming. The political interpretations have become badly dated in the three years that elapsed between the preparation of the papers and publication of the volume. This is a pity.

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Estimates of Israel's International Transactions of 1952-1954, Nadav Halevi. Jerusalem: Falk Project for Economic Research in Israel, 1956. Pp. 139. $2.00.

Results of an empirical inquiry into Israel's balance of payments position are presented in this book.[1] The author's estimates of the country's international transactions are introduced in two forms: First in the standard IMF[2] form for reporting balances of payments, and second, in an al-

[1] The book is part of a program of empirical research in Israel which is financed by the Falk Foundation of Pittsburgh and designed to collect and interpret vital economic statistics. The program is directed by Professor Don Patinkin of the Hebrew University, and includes projects on Israel's national income, Israel's agriculture, the public sector accounts of Israel, and the like.

[2] International Monetary Fund.

ternative classification which he offers after an evaluation of the IMF form and its applicability to Israel. Much of the discussion is applicable to countries other than Israel.

The main criticism leveled against the standard IMF presentation of the balance of payments is that it focuses attention on the concept of "compensatory official finance." This concept shows the financing undertaken or proposed by the monetary authorities to provide exchange to cover a surplus or deficit in the balance of payments. It can therefore serve as a measure of the strain on a country's reserve position. Included in the category of compensatory finance are: a) International reserves (monetary gold, official assets abroad, and liabilities to foreign *official* and *banking* institutions); b) liabilities to the IMF and IBRD; c) official transactions in outstanding long term obligations of the reporting country; d) long-term official loans for balancing international transactions; and e) official grants for balancing international transactions. It is a matter of judgment to determine which loans and grants are "compensatory" and which are "special." The decision "rests upon whether the financing was in response to general balance of payments pressure, or whether it was for a particular project or other special purposes." (p. 50)

It is the arbitrariness of the classification into "compensatory" and "special" finance to which the author objects. In the first place, it is extremely difficult to draw a distinction between the two concepts. This is particularly true in underdeveloped countries which are engaged in planned economic development, where on many occasions a deficit is created because of capital import and not vice versa. Second, it seems rather arbitrary to include only liabilities to foreign official and banking institutions in compensatory finance. It often happens, particularly in the case of Israel, that money is borrowed from private individuals and institutions abroad in order to build up foreign exchange reserves.

The alternative classification of international transactions suggested by the author divides the balance of payments into three parts: goods and services, unilateral transfers, and financial claims. Each of these categories is shown briefly in a summary table, and each has a more detailed supporting table. The financial claim account is presented in a form that shows credits and debits rather than movements of net assets.

In the supplementary tables each one of the main items is broken down further. In the merchandise trade, for example, total import is subdivided into imports of consumer goods, intermediate goods, capital goods, and fuel, while total export is divided into export of citrus fruit, diamonds and other exports. All this forms a wealth of data, which not only makes it possible to arrive at all the concepts of "deficit" used in traditional economics (i.e., trade balance, current account balance, etc.), but provides additional information necessary for analysis of economic problems in a de-

veloping economy. The further breakdown of merchandise imports is a case in point. From it, the investigator can derive the extent to which capital import was used for the import of consumer goods as against investment goods. Incidentally, the subclassification of goods and services used in the book is more in proportion to their economic significance than that used in the IMF form. The latter form divides services into six divisions while lumping goods into two (one of which, namely nonmonetary gold movement, is minor) a practice which is quite out of proportion with the importance of these sectors.

It should be stressed that the separation of unilateral transfers in the proposed alternative formulation is of special importance to Israel. It brings out clearly the role played by the unilateral inflow of capital in the Israeli balance of payments.

While the book goes on to discuss the need for, and the availability of, other information, hardly any mention is made of the fact that for economic analysis and for intertemporal comparisons in Israel, most of the import and export figures are too superficial. In a system which contains so many artificial inducements to export and so many artificial impediments to import, and where much of the industrial export depends on imported raw materials, the changes in export figures do not always mean much. It is the value added of these exports, namely the value added to the commodities by Israeli factors of production, that is important. A statement that exports in a certain year covered a higher percentage of total imports than in a previous year, may be of no significance. What is needed both at any one time and for intertemporal comparisons is a ratio of the value added of exports to total imports excluding the part of import which is designed for the production of export goods. To this entire problem the author pays no attention. Some light could be shed on the problem if the breakdown of merchandise imports in the balance of payments included an item "imports for the production of export goods," and at the same time if it was indicated what per cent of total export was value added locally.

Another problem on which the book does not dwell is the type of countries with which the transactions were made. There is a great deal of difference between export to a hard currency country and export to a country with which Israel has a trade agreement. Exports to the latter countries are sold at artificially high prices, but imports from them are also bought at prices higher than those paid on the world markets. These high import prices are in fact a disguised export subsidy.

The book under review makes an important contribution in compiling the data and presenting them in a useful form. It is regrettable, however, that the author did not go further in his explorations, to tackle additional problems.

MORDECHAI E. KREININ

Michigan State University

NEWS NOTES

W. H. ALEXANDER, Associate Professor of dairy marketing at Louisiana State University, will be on sabbatical leave until February 28, 1959, completing requirements for the Ph.D. at the University of Illinois.

WALT ANDERSON, University of British Columbia, has joined the Royal Commission, investigating prices in Canada for the summer. WILLIAM HAVILAND, Macdonald College, Quebec, is working with the Commission for the next year.

JAMES B. ANDREWS, Professor of Farm Management at the University of Illinois, will retire September 30, 1958. He first joined the Illinois staff in 1913.

ROBERT J. ANTONIDES has been promoted to the rank of Associate Professor of Economics at South Dakota State College.

KENNETH L. BACHMAN, Farm Economics Research Division, ARS, is serving on a subcommittee of the Social Science Research Council to investigate the "fragmented pattern of research in agricultural economics."

K. R. BARLOW, formerly at the University of Idaho, has joined the staff of the University of Arizona as Assistant Agricultural Economist.

CHARLES BEER was promoted to Assistant Professor at Michigan State University in January.

ROBERT D. BELL has joined the staff of the Department of Economics at South Dakota State College as Assistant Professor after completing his Ph.D. degree at Cornell University.

CHARLES H. BENRUD has been promoted to the rank of Associate Professor of Economics at South Dakota State College.

ROBERT E. BRANSON was recently promoted to the position of Professor of Agricultural Economics at Texas A and M College.

AUBREY J. BROWN, Head of the Department of Agricultural Economics at the University of Kentucky, was appointed to the Board of Directors of the Federal Reserve Bank of Cleveland for a three year term beginning January 1, 1958.

VICTOR W. BRUCE, formerly of Cambridge University and the Giannini Foundation at the University of California, has recently returned to FAO Headquarters, Rome, after an absence of three years while he served as FAO Mission Chief in Bolivia and as Advisor on Agricultural Planning and Administration in Chile.

DALE BUTZ is on sabbatical leave from Michigan State University until June 1959. This summer he is working with the Illinois Agricultural Association under the sponsorship of the Foundation for Economic Education, and during the academic year, he will be at Harvard University under the Moffett Program.

RALPH CAMPBELL, Head of the Department of Agricultural Economics, Ontario Agricultural College, has been elected President of the Agricultural Institute of Canada. This is the national organization of professional agriculturalists in Canada, with a membership of approximately 3,000.

ROBERT L. CAREY joined the Agricultural Extension staff at the University of Delaware in July.

HAROLD C. M. CASE, Professor of Agricultural Economics and formerly head of the department at the University of Illinois, will retire September 1, 1958, after 46 years of service to the University, the U. S. Department of Agriculture, and other agencies. He was president of the American

Farm Economic Association in 1930 and editor of the *Journal of Farm Economics* in 1936 and 1937.

MARTIN CHRISTIANSON has transferred from Instructor to Extension Specialist in dairy marketing at the University of Minnesota.

ROBERT L. CLODIUS, Professor of Agricultural Economics, has been appointed Associate Dean of the Graduate School at the University of Wisconsin.

FLOYD L. CORTY joined the faculty at Louisiana State University in May as Assistant Professor in land economics.

EDWARD DAILEY has been appointed Assistant Professor of Economics at South Dakota State College. He was formerly Assistant Extension Economist.

KENNETH EGERTSON, who received his M.S. from the University of Minnesota in March, has been appointed Extension Specialist in livestock marketing at that institution.

THEO H. ELLIS has resigned as Assistant Agricultural Economist, North Dakota Agricultural College, to accept a position as Agricultural Economist, Farm Economics Research Division, ARS, USDA, located at Alabama Polytechnic Institute, Auburn.

JAMES ESMAY, who has been working with the Agricultural Research Service at Montana State College, has received his M.S. degree at that institution and is being transferred to ARS at the University of Idaho.

MERRILL EVANS has resigned from Michigan State University to accept an appointment with the Iowa Farm Bureau Federation.

WILLIAM EWASIUK, who has been making a study of hedging practices and futures contract for hard spring wheat at Montana State College on a contract with the Agricultural Research Service, was recently made Assistant Professor in the Department of Agricultural Economics and Rural Sociology at that institution.

RALPH FELBERG has been promoted to Assistant Professor of Economics at South Dakota State College.

JOHN L. FISCHER, formerly of Nevada, has accepted the position of Professor and Head of the Department of Agricultural Economics and Rural Sociology, and Economics and Sociology at Montana State College.

W. S. FOLKMAN, Associate Professor in the Department of Agricultural Economics and Rural Sociology, University of Arkansas, is a visiting professor at Michigan State University this summer.

A. F. FURMAN, Farm Economics Research Division, ARS, stationed at Albuquerque, New Mexico, has retired because of disability.

L. P. GABBARD retired June 30 from the position of Professor in the Department of Agricultural Economics, Texas A and M College after 36 years of service. He served as head of the department from 1922 to 1953 and has been on modified service for the last five years.

MASON GAFFNEY has been appointed Associate Professor at the University of Missouri and will assume his duties in September. He is presently on a Ford Foundation Faculty Fellowship at the University of California, Berkeley.

ZVI GRILICHES, Department of Economics at the University of Chicago, has received a two year grant from the National Science Foundation for research on "Econometric Investigations in Technological Change."

REX HELFINSTINE, Economist with the ARS at South Dakota State College, has received his Ph.D. degree from the University of California.

J. A. HODGES, Professor of Agricultural Economics at Kansas State College, has

been named acting head of the Department of Economics and Sociology while GEORGE MONTGOMERY is in Hyderabad, India, with the Kansas State I.C.A. Mission.

ROY E. HUFFMAN has been appointed Dean of Agriculture and Director of the Agricultural Experiment Station at Montana State College.

CLARENCE JENSEN, Assistant Professor of Economics and Agricultural Economics at Montana State College received his Ph.D. degree at Michigan State University at the June commencement.

HARALD JENSEN, formerly at Purdue University, joined the staff of the University of Minnesota as Professor of farm management in July.

SHERMAN E. JOHNSON, scientific and professional advisor, ARS, received a distinguished service award at the honor awards ceremony of the Department of Agriculture in May "for national and world leadership in research on economics of agricultural production and the application of sound economic principles to broad agricultural problems of vital concern to farmers and the nation."

BRUCE F. JOHNSTON returned to the Food Research Institute, Stanford University, in June after a tour of Central Africa, where he explored possibilities for increased consumption of U. S. wheat.

GEORGE G. JUDGE, Professor of Agricultural Economics, Oklahoma State University, has been granted a nine month leave of absence to accept a Social Science Research Council post-doctoral fellowship at Yale University, working with the Cowles Commission.

M. M. KELSO, formerly Dean of the College of Agriculture, Montana State College, has joined the staff of the University of Arizona as Professor of Agricultural Economics.

HARRY J. KORSLUND, JR. recently joined the staff at the University of Arkansas as a Cooperative Agent with AMS and the Experiment Station.

BALDUR KRISTJANSON left the Canadian Department of Agriculture in June for two years in Iran on a Ford Foundation program of research and development.

LEONARD KYLE was promoted to Associate Professor at Michigan State University effective July 1. He is, at present, in the middle of a two year assignment in Colombia working with the agricultural colleges at Medellin and Palmira.

BUEL F. LANPHER, JR., has accepted a position with the Division of Agricultural Economics Programs, Federal Extension Service. He is replacing JACK CLAAR as head of the Farm Management and Production Economics Branch.

DAVID E. LINDSTROM, Professor of Rural Sociology, University of Illinois, conducted a world mission inspection tour, July-August 1958. Government and church missions from Greece to Japan were visited. The tour also included farm visits throughout Europe and the Scandanavian countries.

JAMES G. MADDOX joined the staff as Professor of Agricultural Economics at North Carolina State College July 1.

TRAVIS W. MANNING has been promoted to the rank of Professor of Economics at South Dakota State College.

ROBERT G. MARSHALL, Assistant Professor in the Department of Agricultural Economics, Ontario Agricultural College, has been awarded a Canada Council grant to continue doctoral studies at the University of Toronto.

RICHARD MCCONNEN, who had been on leave to continue his Ph.D. degree

work at Michigan State University, returned to his post as Extension Economist at Montana State College July 1.

KENNETH MCLENNAN has been appointed Assistant in the Department of Agricultural Economics, Ontario Agricultural College, to undertake teaching and research in Business Management. He is a graduate of the Scottish School of Commerce and London University.

CARL D. MEADOR has accepted a position in the milk market administrator's office at Dallas, Texas.

S. W. MENDUM, Farm Economics Research Division, ARS, retired in April after nearly 40 years service in the U. S. Department of Agriculture.

C. CLYDE MITCHELL, formerly advisor on national planning to the government of Mexico in a United Nations Technical Assistance (FAO) post, joined the Harvard Advisory Group to the Pakistan Planning Board last October as advisor in Finance and International Trade.

CLARENCE A. MOORE was recently promoted to the position of Associate Professor of Agricultural Economics at Texas A and M College.

JOHN MOORE has been appointed Assistant Professor in marketing extension at Michigan State University effective August 1, after receiving his Ph.D. degree from the University of Wisconsin this summer.

WILLARD F. MUELLER has been promoted to Associate Professor of Agricultural Economics at the University of Wisconsin.

MAX MYERS, Director of the South Dakota Agricultural Experiment Station, has been appointed Director of the U. S. Foreign Agricultural Service. He assumed his new duties July 1, under a leave of absence from South Dakota State College.

A. G. NELSON, formerly Director of Research and Education, Omaha Farm Credit District, has joined the staff of the University of Arizona as Professor of Agricultural Economics.

S. DANIEL NEUMARK returned to the Food Research Institute, Stanford University, in May after serving for several months as a consultant on African Economic Development at a United Nations headquarters.

MERTON L. OTTO, Associate Professor of Agricultural Economics at Kansas State College, has returned from an assignment with I.C.A. in Jamaica.

JEROME K. PASTO will be on extended leave from Pennsylvania State College as a consultant on farm management for the FAO. He is engaged in planning and conducting a series of seminars on farm management work in the Asia-Pacific Region.

WALTER E. PAULSON, retired April 30 from the position of Professor in the Department of Agricultural Economics, Texas A and M College, after 30 years of service.

ANTHONY L. PAVLICK has been promoted to the rank of Associate Professor of Economics at South Dakota State College.

E. LOUISE PEFFER has been promoted to Economist and Professor in the Food Research Institute, Stanford University.

GUSTOF A. PETERSON, formerly Agricultural Economist at the Federal Reserve Bank of Kansas City, has accepted a position as Associate Professor with the Department of Agricultural Economics at the University of Wisconsin effective September 1.

GEORGE A. POND, Professor of farm management, University of Minnesota, retired June 30 after 41 years of service. He was vice-president of the AFEA in 1940.

HORACE PUTERBAUGH, Farm Economics Research Division, ARS, formerly stationed at Connecticut, has joined the Washington staff of the Division.

M. E. QUENEMOEN, who has been on leave to continue work toward his Ph.D. degree at Michigan State University, returned to his post as Extension Economist at Montana State College July 1.

JOHN R. RAEBURN, London School of Economics, has returned to East Africa for four months in connection with his study of the economics of farming systems in Africa in which 12 Territorial Governments are cooperating.

WILLIAM RAILING returned to South Dakota State College after receiving his Ph.D. degree at Cornell University. He has been promoted to the rank of Associate Professor.

PHILIP M. RAUP is one of 12 University of Minnesota professors making a 30 day travel seminar tour of the Soviet Union. The tour is sponsored by the Hill Family Foundation for the purpose of promoting greater understanding of the USSR in the classroom and in the community.

EDWARD RENSHAW has been appointed to the faculty of the University of Chicago, Department of Economics, as instructor. He will concentrate his new work on the economics of education.

NORMAN KEITH ROBERTS, Associate Professor at Utah State University, received his Ph.D. degree from the University of Kentucky in June. He was formerly on the staff at the University of Florida.

JAMES B. ROOF has joined the staff of the Dairy Branch, Farmer Cooperative Service, after completing requirements for an M.S. degree at Michigan State University.

CLYDE ST. CLERGY, formerly instructor in agricultural economics at Louisiana State University, is now conducting research in forest products marketing at the North Louisiana Hill Farm Experiment Station at Homer.

A'DELBERT SAMSON of the Department of Agricultural Economics and Rural Sociology at Montana State College is on leave to study in Sweden during spring and summer quarters, 1958.

FRED B. SAUNDERS, Assistant Agricultural Economist at the University of Georgia Experiment Station, received his Ph.D. degree from Iowa State College in June.

JOHN SCHNITTKER, Assistant Professor of Agricultural Economics at Kansas State College, has been granted one year leave of absence to join the staff of the Council of Economic Advisors in Washington.

WILLIAM E. SCHRUMPF, Associate Agricultural Economist, Maine Agricultural Experiment Station, retired June 30 after 30 years of service.

THEODORE W. SCHULTZ, Department of Economics at the University of Chicago, has recently been added to the trustees of the Population Council, which is financed mainly by John D. Rockefeller, the Ford Foundation, and the Rockefeller Brothers fund.

C. H. SEUFFERLE has been appointed Head of the Department of Agricultural Economics at the University of Nevada.

JAMES D. SHAFFER was promoted to Associate Professor at Michigan State University effective July 1, 1958.

ROY J. SMITH, formerly Vice Chairman of the Department of Agricultural Economics, has been named Assistant Dean of the College of Agriculture at the University of California, Los Angeles. He will have charge of development work for the new curricula in agricultural management and agricultural production and will continue his teaching and research duties.

WESLEY G. SMITH, who recently completed his Ph.D. requirements at Iowa State College, joined the Agricultural Economics staff at the University of Delaware in May.

JAMES L. STALLINGS joined the staff of the Department of Agricultural Economics at New Mexico A and M as Assistant Professor in February. He has been taking work for his Ph.D. at Michigan State University.

JASPER STEVENS graduated in June at Texas A and M and is an associate in research at Louisiana State University.

EARL R. SWANSON, Associate Professor of Agricultural Economics, University of Illinois, participated in the Farm Management Research Institute held at Hokkaido University, Sapporo, Japan, during July and August. He also attended the tenth International Conference of Agricultural Economists in Mysore City, India, and will spend the academic year 1958-59 at Royal College of Agriculture and Veterinary Medicine in Copenhagen, Denmark, under a Fulbright grant.

BORIS C. SWERLING returned to Stanford University in June after serving for two years on the staff of the President's Council of Economic Advisors. He will resume work at the Food Research Institute in September, after pursuing work in the Stanford Law School during the summer under a grant from the Rockefeller Foundation.

BYRON TAYLOR, Assistant Instructor of Agricultural Economics at Kansas State College, has accepted a position as marketing specialist with the Wyoming extension service.

JOHN E. THOMPSON has been promoted to the rank of Associate Professor of Economics at South Dakota State College.

GEORGE S. TOLLEY was promoted to the rank of Professor of Agricultural Economics at North Carolina State College July 1.

SYKES TRIEB has been appointed extension specialist in market-retailing at Kansas State College.

WINSTON K. ULLMAN has been promoted to the rank of Associate Professor of Economics at South Dakota State College.

ORION (CHERRY) ULREY has been granted a two year leave of absence from Michigan State University to participate in the University of Missouri Contract Program in Eastern India. He will work in the area of Orissa, W. Bengal, Bihar, and Assam, India.

NORMAN R. URQUHART has been promoted to Associate Economist at the First National City Bank of New York where he heads the Commodity Section of the Economics Department.

HILDA WEBER of Bonn, Germany, will be a guest of the Department of Economics at the University of Chicago where she will continue to concentrate on her studies in agricultural economics.

JERRY WEST joined the staff of the Department of Agricultural Economics at the University of Missouri as Assistant Professor. He received his Ph.D. from Michigan State University in March.

GEORGE W. WESTCOTT, Extension Professor in Agricultural Economics at the University of Massachusetts has left for Sapporo, Japan, and will spend two years on the staff of Hokkaido University in a teaching and advisory capacity. SHINZABURO ASUWA of Hokkaido University is spending one year on the staff of the Agricultural Economics Department of the University of Massachusetts and will study the cooperative movement, laws, and practices in the United States.

JOHN M. WETMORE is now Agricultural Economist with the Federal Reserve Bank of Chicago. He was formerly a Research Fellow at the University of Minnesota.

HOWARD S. WHITNEY, Assistant Professor of Agricultural Economics at Texas A and M College, was selected as recipient of the Charles N. Shepardson Award of $500 for excellence in teaching in the 1958-59 school year.

WALTER W. WILCOX, Senior Specialist in Agriculture, Library of Congress, has accepted a position as Visiting Professor of Agricultural Economics at the University of Minnesota for the fall quarter, 1958.

KARL WRIGHT has been assigned to the University of Ryukyus, Okinawa, as chief of the Michigan State Advisory Mission. He left during July to take over the post for a two year period.

FRANCIS P. YAGER has accepted a position as agricultural economist with the Grain Branch, Farmer Cooperative Service.

JOHN ZIMMER, Farm Economics Research Division, ARS, transferred from North Dakota to Utah, where he will work on the Upper Colorado River Basin research program.

THE UNIVERSITY OF CHICAGO has received a grant of $125,000 from the Ford Foundation for comparative studies of agricultural policy and economic growth. The studies will be under the direction of Theodore W. Schultz and D. Gale Johnson.

THE FOOD RESEARCH INSTITUTE, Stanford University, has received an additional five year grant of $200,000 from the Carnegie Corporation for continued research on economic development in Africa south of the Sahara with particular reference to agriculture.

DIRECTORY OF WORKERS IN THE ECONOMICS OF FORESTRY

The Division of Forest Economics and Policy of the Society of American Foresters is compiling a directory of people in the United States and Canada who are working currently in the general area of the economics of forestry. The utility of the directory in facilitating contacts among workers with common interests, in opening up lines of communication for workers in fringe areas, and as a fund of personal data depends in large measure upon its inclusiveness. If your present work or interest treats the economics of production, harvesting, processing, marketing or consumption of forest products and services from any viewpoint, please write to Professor A. C. Worrell, 360 Prospect Street, New Haven 11, Connecticut, for a data sheet.

NOTICE

Copies of a bibliography on "Liberal Education and Agriculture," compiled by Wayne D. Rasmussen, are available free upon request of individuals to The Institute of Higher Education, Teachers College, Columbia University, New York 27, New York.

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Underemployment in Backward Economies: An Empirical Comment .. HARRY T. OSHIMA

Reply ..... HARVEY LEIBENSTEIN

Book Reviews and Books Received

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